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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Illustrated Advertisement Page 10, Nov. 5.

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See page 17, Nov. 5. 8205

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See page 18, Nov. 5. 8421

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See Advertisement page 103.

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CARDIFF WAREHOUSE—123, BUTE ST.
BIRMINGHAM WAREHOUSES—NILE STREET, SHEEPCOTE STREET.
See Advertisement page 30. 8157

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Great saving of labour. No noise. No dust. No dirt. Ashes discharged 30 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4026

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MOTOR-DRIVEN PLANING MACHINE,
To plane 30 ft. by 30 ft. by 10 ft., four Tool Boxes. Condition as new. Makers, Buckton & Co.
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See Advertisement page 86, Nov. 5. 2402

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Works: HURST MILL, near HARLOW, HERTS.
Makers of
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See Advt. Page 124, Nov. 5.
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TENDERS.

THE ASSAM-BENGAL RAILWAY COMPANY, LIMITED,
is prepared to receive

Tenders for :—

STRUCTURAL STEELWORK, GALVANIZED WORK, &c., for SHOPS EXTENSION.

Specifications and Tender Forms may be obtained at the offices of the Company, Bishopsgate House, 80, Bishopsgate, E.C. 2. Drawings may be had at the cost of the tenderer by application to Messrs. Rodgers, Bennett and Co., Ltd., 78, Queen Victoria Street, E.C. 4.

Tenders must be delivered at the Company's offices, not later than Noon on Wednesday, the 1st December, 1920.

The Directors do not bind themselves to accept the lowest or any Tender.

By order of the Board,
OSWALD I. MILNE,
Secretary. K 644

GREAT SOUTHERN & WESTERN RAILWAY (IRELAND).

CONTRACTS 1921.

The Directors of the Great Southern and Western Railway Company are prepared to receive

Tenders for the Supply of the

undermentioned STORES for Three Months commencing 1st January, 1921.

	No. of Form.		No. of Form.
Baskets	10	Incandescent Fittings for Gas	26c
Bolts, Nuts and Rivets	15	India Rubber Goods	9a
Brooms and Brushes	13	Implements, Sundry	21
Brass Fittings for Carriages	18	Iron Tubes and Fittings	29
Do. do. for Lamps	18a	Iron and Steel Wire	30a
Do. do. for Water	26a	Leather	13
Do. do. for Gas ...	26a	Linen	8
Bunting	7a	Locks and Keys ...	19
Canvas and Sacks ...	6	Mats, Fibre	10
Carriage Laces ...	7a	Morocoes	7a
Castings, Mall. Iron	11	Nails	31
Cloth, Carr. and Uniforms	7c	Oak Keys	35a
Clothing, Oil ...	9a	Oak Trenails	35b
Do. I.R. proofed	9a	Plumbago	41
Coach Screws and Washers	15	Railway Fastenings (Iron)	16
Colours	2	Railway Fastenings (Steel)	16a
Corks	39	Rain Water Pipes and Gutters	25
Cotton Waste ...	5a	Ropes, Twine, and Yarn	4
Crucibles	41	Sewer Pipes, Plaster, etc.	32
Drysalteries	3	Shovels, Spades, etc.	21a
Emery and Glass Cloth, etc.	36	Soft Goods	8
Files and Tool Steel	30	Sponge Cloths ...	5
Fire Bricks and Clay	33	Signal Wire Pulleys	11
Foundry Requisites	42	Screw and Split Pins	14
Galv. Sheets, Buckets, etc.	23	Tin Plates	22
Grates, Stoves and Fenders	24	Varnishes	1
Grindstones	28	Waste	5a
Glass, Sheet, and Plate	37a	Waterproof Clothing	9a
Glass and China Sundries	37b	Wicks	5
Hardware (Sundry)	17	Wire, Fences and Signal	30a
		Wirework	30b

Forms of Tender can be obtained on *PAYMENT* of 6d. each from the STORES SUPERINTENDENT, GENERAL STORES DEPARTMENT, G.S. & W.R., INCHICORE, DUBLIN. Applications for forms by Post must be accompanied by Postal Order. Stamps cannot be accepted. All enquiries for information should be also directed to the Stores Superintendent.

Patterns may be inspected at the General Stores Department on and after the 12th inst, between the hours of Ten a.m. and Four p.m. (except on Saturdays).

Tenders must be enclosed in the special envelope supplied for the purpose with each schedule, and must be posted so as to be with the undersigned before Ten a.m. on Wednesday, 24th November, 1920.

The Directors will not consider any Tender unless it is furnished on the Company's Form, and do not bind themselves to accept the lowest or any Tender.

ROBERT CRAWFORD, Secretary.
Kingsbridge Terminus, Dublin,
November, 1920. K 639

INDIA OFFICE,
WHITEHALL,
11th November, 1920.

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders from such Persons as may be willing to SUPPLY—

AXLES.
FISHBOLTS, NUTS AND GROVER'S WASHERS.
POINT RODDING.
SCREW COUPLINGS. (1)
TYRES, STEEL.

LOCOMOTIVE BOILERS. (2)

The Conditions of Contract may be obtained on application to the Director General of Stores, India Office, Whitehall, S.W. 1, and Tenders are to be delivered at that office by Two o'clock p.m. on Friday, the 26th November, 1920, for No. 1, and on Friday, the 3rd December, 1920, for No. 2, after which times respectively no Tender will be received.

G. H. COLLIER, K 633
Director General of Stores.

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of :—

3,000 HYEBOLTS and
480 COILS of STRAND WIRE for Fencing.

For each copy of the Specification a fee of 20s. will be charged, which fee is not returnable. Tenders enclosed in sealed envelopes addressed to the "Chairman and Directors" and endorsed "Tender for Hyebolts and Strand Wire for Fencing" must be delivered at the Company's Offices not later than Twelve noon on Monday, 22nd November, 1920. The Directors do not bind themselves to accept any or the lowest Tender, and reserve the right to divide the order.

By order of the Board,
W. HOME,
Managing Director.

199, Gresham House,
Old Broad Street,
London, E.C. 2.
11th November, 1920. K 663

CORPORATION OF DUBLIN.

NOTICE TO ENGINEERS AND IRON FOUNDERS.

The Paving Committee of the Corporation of Dublin are prepared to receive

Tenders for the Supply and

ERECTION, in Dublin, of PLANT for the Manufacture of Tar Macadam, Asphaltic Concrete, and Asphaltic Surface Coat.

Copies of the Specification, and Instructions for Tendering, may be obtained on application to the undersigned.

Tenderers will be required to enter into a Contract and Bond with the Corporation, embodying the usual Corporation conditions, and to submit the names of two solvent persons to be bound in a sum equal to 50 per cent. of the Contract amount for the due performance of the Contract.

Tenders, sealed and endorsed "Tender for Asphaltic Macadam Plant," should be addressed to the Chairman of the Paving Committee, City Hall, Dublin, and delivered at the Office of the undersigned not later than Twelve o'clock, noon, on Tuesday, 4th January, 1921.

The Corporation do not bind themselves to accept the lowest or any Tender.

By Order,
PATRICK TOBIN,
Secretary, Paving Committee.
City Hall, Dublin,
4th November, 1920. K 614

G. R.

MINISTRY OF MUNITIONS.
BY DIRECTION OF THE DISPOSAL BOARD.
(Plant & Machinery Section.)
CRANES.

Sale by Public Tender.

ONE ELECTRIC COAL GRABBING CRANE.

Hammer head type fitted with Hoisting, Traversing, and slewing motions, with all necessary Electrical and Mechanical gear. Grab by Priestman Bros., of 4 rope, centre shaft design.

Grab capacity, Flush 34 cu. ft.
Grab capacity, Heaped 41 cu. ft.
Weight of Grab empty, 37 cwts.
Effective Radius, 55 ft.
Height from Crane Pedestal to under-side of Cantilever arm, 32 ft.
Height of lift, 38 ft. (about).
Lowest Grabbing position below Crane Pedestal, 14 ft.
Current Supply, 440 volt, 3 phase, 50 cycles.
Capable of handling from 20 to 25 tons per hour.
LYING AT: Messrs. Herbert Morris, Ltd.(makers), Loughborough. Reference M.K. 36138.

HAND CRANES AT THE ROYAL MINING DEPOT, IMMINGHAM.

22 Double Girder Morris "G" type, Hand Power Overhead Travelling Cranes. Distance between Rails and Floor 16 ft. Working load 1 ton. Test load 1½ tons. Span between rails 34 ft. 3 in. Reference M.K. 47322–47342.

One ditto as above, but working load 1½ tons. Test load 2¼ tons. Reference M.K. 47344.

3 Hand Travelling Rail Cranes. Single and double purchase lifting gear. Jib of Steel joist, and long enough to give a radius of 15 ft. Under carriage mounted on 4 single flange C.I. Wheels. Will lift working load of 20 cwt. on double gear, and loads up to 10 cwt. on single gear. Working load is 20 cwt., test load 30 cwt. By Carrick & Ritchie, Edinburgh. Reference M.K. 47345–6 and 7.

One Hand Travelling Crane. No gear for slewing motion as Crane can be easily slewed by hand. 4 Carriage wheels, single flange O.I. 2 ft. dia. Radius of Crane is 24 ft. and height from underside of Hook to Crane 34 ft. Rope of flexible wire with factor of safety of not less than 5. Necessary Brakes for lifting and Travelling fitted. Rail gauge 4 ft. 8½ in. Working load 10 cwt. Test load 15 cwt. By G. Russell & Co. Reference M.K. 47348.

Full Specification of Grabbing Crane, detailed particulars of other Cranes, Permits to view, and tender forms can be obtained on application to the Controller,

D.B.I.E.
Charing Cross Huts, W.C. 2.

Tenders to be completed and returned on or before ten a.m. on the 7th December, 1920. K 647

BOMBAY MUNICIPALITY.

REFUSE DESTRUCTOR.

Proposals will be Received

by the Municipal Commissioner for the City of Bombay up to the 4th day of March, 1921, for the complete MANUFACTURE, ERECTION and EQUIPMENT of a REFUSE DESTRUCTOR within the City, for the incineration of 300 tons of refuse per day.

A copy of the particulars and general conditions for tenderers and plan of the proposed site can be obtained, on payment of Five Shillings which will not be returned, from Sir John Wolfe Barry, Lyster & Partners, Dartmouth House, 2, Queen Anne's Gate, Westminster, London, S.W. 1, who will also give inspection of the schedule of rates for materials, labour, etc., prevailing in Bombay.

H. B. CLAYTON, I.C.S.,
Ag. Municipal Commissioner
for the City of Bombay.

Municipal Offices,
Bombay, India. K 628

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of :—

1. COPPER PLATES.
2. SUPERHEATER ELEMENTS.
3. STEEL TYRES.

Specifications and Forms of Tender may be obtained at the Company's Offices, 91, York Street, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked :—"Tenders for Copper Plates" or as the case may be, must be left with the undersigned not later than Two p.m. on Tuesday, the 30th November, 1920.

A charge, which will not be returned, will be made of 10s. for each copy of the Specifications Nos. 1 and 2, and 20s. for each copy of Specification No. 3. Copies of the drawings may be obtained at the office of Robert White, Esq., M.Inst.C.E., Consulting Engineer to the Company, 2, Victoria Street, Westminster, S.W. 1.

By Order,
(Sgd.) W. B. REYNOLDS,
for Managing Director.

91, York Street,
Westminster, S.W. 1.
3rd November, 1920. K 613

APPOINTMENTS OPEN.

THE COUNCIL OF THE RESEARCH ASSOCIATION OF BRITISH MOTOR AND ALLIED MANUFACTURERS invite

Applications for the Post of

ASSISTANT DIRECTOR OF RESEARCH.

Applications, with copies of three recent testimonials, should be posted as soon as possible to the R.A.B.M.A.M., Room 638, Ulster Chambers, Regent Street, W. 1, and the envelope marked "Candidate." Engineering experience, scientific training and brief sketch of career should be given. No one without first-class scientific qualifications should apply. State salary expected. K 635

NOTICE.

THE DUBLIN PORT AND DOCKS BOARD require the

Services of a Gentleman

fully qualified to act as MANAGER of their CUSTOM HOUSE DOCKS and WAREHOUSES. Applications to be confined to persons with experience of Warehousing Goods and General Dock work. Age not to exceed 35 years. Salary commencing at £800 per annum. Appointment to be for a period of twelve months on probation, and subject to confirmation by the Board on the expiration of this period. Security will be required.

Sealed Applications, in writing, stating age and qualifications, and enclosing copies only of Testimonials and endorsed on the envelope "Manager, Custom House Docks" will be received addressed to the undersigned up to 1st January, 1921.

By Order,
N. PROUD, Secretary.

Port and Docks Offices,
Westmoreland Street, Dublin.
6th November, 1920. K 640

UNIVERSITY COLLEGE, JOHANNESBURG.

The Council Invites

Applications for the following

APPOINTMENT:

JUNIOR LECTURER AND DEMONSTRATOR IN THE DEPARTMENT OF MECHANICAL ENGINEERING.

Applicants must have had technical training, workshops, and preferably also drawing office experience. Salary £354 per annum, rising by £27 10s. annually to £464. War bonus at Government rates: at present £26 per annum for single man, £114 if married. Appointment probationary for first two years. Applicant with special qualifications may possibly be appointed at higher rate than specified. Duties commence about 1st March, 1921. Allowance for travelling expenses £40. Half salary from sailing until arrival. Medical certificate required before appointment. Age to be stated. Applications and testimonials, all in triplicate, to be sent by 6th December to CHALMERS, GUTHRIE & Co., Ltd., 6, Idol Lane, London, E.C. 3. K 669

CHESHIRE COUNTY COUNCIL.
EDUCATION DEPARTMENT.

NORTHWICH VERDIN TECHNICAL SCHOOL AND SCHOOL OF ART.

Principal: D. N. Griffiths, B.Sc., A.M.I.Mech.E.

Applications are Invited for

the undermentioned POSTS :—

1. PRINCIPAL of the above-named School and Headmaster of the Voluntary Day Continuation School connected therewith. Candidates should possess a good degree in Engineering or an equivalent qualification. Inclusive annual salary £540–£25–£700.
2. FULL-TIME ASSISTANT in the Engineering Department, mainly to teach Workshop Processes. Annual Salary £300–£20–£450.

Forms of Application and further particulars may be obtained from the undersigned.

C. F. MOTT,
Director of Education.

County Education Offices,
City Road,
Chester. K 621

CITY OF CARDIFF EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.
Principal: Charles Coles, B.Sc. (Lond.).

The Services are Required as

soon as possible, of an ASSISTANT LECTURER in the Engineering Department, whose duties will be concerned mainly with laboratory work.

Commencing salary £350 per annum, rising by annual increments of £30 to £450 per annum.

Applicants should have had good teaching experience, experience in the Engineering Laboratory of a Technical College, together with workshop training. He should be able to keep the equipment in good condition and to help with the design and manufacture of additional apparatus.

Applications on foolscap paper, stating age, full qualifications, teaching and other experience, and giving copies of not more than three recent testimonials, should reach the PRINCIPAL on or before Wednesday, November 17th, 1920.

JOHN J. JACKSON, B.A.,
Director of Education.

City Hall,
Cardiff. K 547

NEWCASTLE-UPON-TYNE EDUCATION COMMITTEE.

RUTHERFORD TECHNICAL COLLEGE.

Required, by 6th January,

1921, an ASSISTANT LECTURER in ENGINEERING, at a commencing salary of £350. Sound technical education, works experience, and a degree (or its equivalent) essential.

Further particulars, conditions of appointment, and form of application (to be returned as soon as possible) from the undersigned.

THOS. WALLING,
Director of Education.

Northumberland Road,
Newcastle-upon-Tyne. K 623

CITY OF BIRMINGHAM ELECTRIC SUPPLY DEPARTMENT.

ASSISTANT CONSTRUCTIONAL ENGINEER.

An Assistant Engineer is Required

to assist the Constructional Engineer in the preparation of specifications and plans for new buildings and lay-out of new steam and electrical plant and in superintending the erection and testing of such plant. He should have served an apprenticeship as a Mechanical Engineer and taken a full University Engineering course. Experience in the latest practice as applied to large electric generating stations will also be taken into account.

Salary will be at the rate of £570 per annum which includes, B.P.E.A. Awards.

The successful candidate will be required to undergo an approved medical examination and contribute to the Corporation Superannuation scheme.

Forms of application for the above appointment may be obtained from the undersigned, and when completed should be sent to these offices, with copies of not more than three testimonials as to experience, ability and character, addressed to Mr. R. A. Chattock, City Electrical Engineer. Applications endorsed "Assistant Constructional Engineer," must be sent in not later than November 18th.

E. J. JENNINGS,
Secretary.

14, Dale End,
Birmingham. K 543

CORPORATION OF CALCUTTA.

CIVIL ENGINEER—WANTED.

The Corporation of Calcutta require the

Services of a Properly

qualified CIVIL ENGINEER. He will be under the direction of the Chief Engineer and will be required to devote his whole time to his duties and will not be allowed to take up any private work. His duties will consist mainly in inspecting and reporting on the Improvement Works carried out by the Calcutta Improvement Trust while these works are in progress and before they are taken over for maintenance by the Corporation of Calcutta. He will be required to reside in Calcutta.

The appointment is subject to the Provident Fund, leave and other service rules of the Corporation and may be terminated at any time by 6 months' notice on either side. The Provident Fund contribution is 6¼ per cent. of the monthly salary and an equivalent amount is contributed by the Corporation and the fund accumulates at compound interest. The selected candidate will be required to submit to a medical examination before joining his appointment. He will be required to take up his duties within two months of the date of receiving notice of appointment.

B. The salary of the appointment is fixed at Rs. 1,000 per month. The person appointed will be required to keep a motor car, for the upkeep of which an allowance of Rs. 100 per month will be made. There are no other allowances. The cost of the motor car will, if desired, be advanced by the Corporation and recovered in monthly instalments spread over a period of not more than three years.

C. Preference will be given to candidates who are Corporate Members of the Institution of Civil Engineers or Graduates in Engineering of a University and have had experience of Construction of General Municipal Engineering and City Improvement Works particularly in regard to Water and Drainage Works and Modern methods of Road Construction.

D. Applications should be accompanied by copies of recent testimonials and a medical certificate of fitness for service in India. Candidates should state age and whether married or single.

E. The Corporation will pay 1st class passage from London to Calcutta but the amount so paid will require to be refunded if the person appointed leaves the service of the Corporation within two years of the date of joining his appointment. Half pay will be paid for the period occupied by the journey to Calcutta.

F. Applications will be received in the United Kingdom up to the 1st December, 1920, by W. C. Easton, Esq., B.Sc., M.Inst.C.E., 140, West George Street, Glasgow, from whom any further information may be obtained.

J. C. MUKERJEA,
Secretary to the Corporation.
Central Municipal Office,
Calcutta, the 12th October, 1920. K 599

THE MATHEMATICAL THEORY OF A METHOD OF BOILER FEED-WATER HEATING IN STEAM TURBINE-DRIVEN POWER STATIONS.

By Robert Dowson, B.Sc. (London).

(*Concluded from page* 595.)

Section (3). Practical Considerations.

The discussion in the previous article showed the possibilities of this method of feed-water heating from a theoretical point of view, but in actual practice, our difficulties are very great; for instance—

1. It is not possible to have anything like an infinite number of heating stages. Two or three feed-water heaters only, make the pipe arrangement quite complicated enough.

2. It is not possible to introduce the heating steam directly into the feed water as it is being pumped back to the boilers because at every point of tap-off the former is at a lower pressure than the latter.

3. The volume of steam to be dealt with in the heaters towards the exhaust end becomes very formidable.

It therefore becomes necessary in practice (and as is actually done), to use surface heaters, and to content ourselves with three or four of them. With this arrangement, the drain from each heater (*i.e.*, the condensed heating steam) would be run into the one before, and so on, so that the total heating steam condensate is cooled down by successive stages, until finally it enters the suction pipe of the extraction pump of the main condenser, and there mixes with the main condensate.

Let us investigate this case of practical import, mathematically. We shall first show that, in the limit, when the number of heaters becomes infinite, we obtain the same result as before, namely:

$$\frac{w}{Q} = 1 - e^{\lambda (T_1 - T)}$$

at any point where the temperature is T deg. absolute.

So that, as we should expect, it does not matter, from a theoretical point of view, whether the heating steam mixes with the feed water or not. We note that, as the condensate from the heaters does not now mix with the main condensate until the condenser is reached, it follows that Q, the total feed to be heated up in any feed heater, remains constant in magnitude, and is equal to the total steam consumption of the turbine.

Let n be the number of feed-heaters,

$\frac{R}{n}$ = the rise in temperature of the feed water Q as it passes through each heater, where

$$\frac{R}{n} = \frac{T_1 - T_n}{n}$$

and $T_1 - T_2$ = the total rise in temperature in the feed water.

The increases in temperature of the feed water at each feed heater are therefore assumed to be equal.

Now, the total rise in the feed-water temperature in the heaters is $T_1 - T_n$, where T_n = the temperature of the feed water as it enters the first heater. But T_n is not equal to T_2, the main condensate temperature, in the case of a finite number of heaters, because the drain water from all the heaters (the total condensed heating steam), leaves the lowest heater at the steam temperature of the latter, which will be considerably above that of the main condensate. When therefore, the heating steam condensate and the main condensate mix, there will be a resultant temperature rather higher than T_2.

In other words, if T_2 is the main condensate temperature (in the condenser), then T_n is given by the relation:

$$\sigma \cdot \Sigma(x) \cdot \frac{R}{n} = \sigma \{ Q - \Sigma(x) \} (T_n - T_2) \quad . \quad (15)$$

$\Sigma(x)$ being the total steam tapped off.

The calculation of T_n by this equation, in a practical case where there are but two or three heaters, involves an immense amount of algebra, and the slight difference between T_n and T_2 (only a few degrees), does not justify the immense labour involved. It will be sufficient, for ordinary calculation, to add on a few degrees to T_2, the main condensate temperature, or to calculate it approximately.

We note that, in the ideal case, where the number of heaters is indefinitely great, then R/n becomes indefinitely small, so that in the limit $T_n = T_2$, and the error disappears. Hence, if in the practical case x = the pounds of steam/hour to be tapped off at any heater, we have, reckoning the heaters from the steam end:—

At the first heater:

$$Q \cdot \sigma \frac{R}{n} = x_1 \cdot q L,$$

the latent heat only being utilised:

$$\text{Let } \sigma \frac{R}{n} = \gamma = \text{constant}$$

$$\text{and } q L = a = \text{constant},$$

$$\text{i.e., } Q \cdot \gamma = x_1 a$$

but at the second heater:

$$Q \cdot \gamma = x_2 a + x_1 \gamma$$

and at the third heater:

$$Q \cdot \gamma = x_3 a + x \gamma_2 + x_1 \gamma,$$

and so on; at the nth heater:

$$Q \cdot \gamma = x_n a + x_{n-1} \gamma + \ldots + x_1 \gamma.$$

We thus obtain:

$$x_1 = Q \frac{\gamma}{a}$$

$$x_2 = \frac{Q\gamma - x_1 \gamma}{a} = \frac{Q\gamma - Q\frac{\gamma}{a}\gamma}{a} = \frac{Q\gamma\left(1 - \frac{\gamma}{a}\right)}{a}$$

similarly:

$$x_3 = \frac{Q\gamma - x_1\gamma - x_2\gamma}{a} = \ldots = \frac{Q\gamma}{a}\left(1 - \frac{\gamma}{a}\right)^2$$

and so on; so that we have:

$$x_1 + x_2 + x_3 + \ldots + x_n = \Sigma(x) = W$$

$$= Q\frac{\gamma}{a}\left\{1 + \left(1 - \frac{\gamma}{a}\right) + \left(1 - \frac{\gamma}{a}\right)^2 + \ldots \left(1 - \frac{\gamma}{a}\right)^{n-1}\right\}$$

which is a geometrical progression whose common ratio is

$$\left(1 - \frac{\gamma}{a}\right);$$

and the sum to n terms is accordingly

$$S = \frac{1\left\{\left(1 - \frac{\gamma}{a}\right)^n - 1\right\}}{\left(1 - \frac{\gamma}{a}\right) - 1} = \frac{\left(1 - \frac{\gamma}{a}\right)^n - 1}{-\frac{\gamma}{a}};$$

hence

$$W = Q\frac{\gamma}{a} \cdot \frac{\left(1 - \frac{\gamma}{a}\right)^n - 1}{-\frac{\gamma}{a}} = Q\left(1 - \left(1 - \frac{\gamma}{a}\right)^n\right) \quad . \quad (16)$$

Now

$$\left(1 - \frac{\gamma}{a}\right)^n = 1 - n\frac{\gamma}{a} + \frac{n(n-1)}{2!}\left(\frac{\gamma}{a}\right)^2 - \frac{n(n-1)(n-2)}{3!}\left(\frac{\gamma}{a}\right)^3 + \ldots$$

also

$$\frac{\gamma}{a} = \frac{\sigma R}{n q L}$$

so that

$$\left(1 - \frac{\gamma}{a}\right)^n = 1 - \frac{n\sigma R}{n q L} + \frac{n(n-1)}{2!}\frac{(\sigma R)^2}{n^2 (q L)^2} - \frac{n(n-1)(n-2)}{3!}\frac{(\sigma R)^3}{n^3 (q L)^3} + \ldots = 1 - \frac{\sigma R}{q L} + \frac{1\left(1 - \frac{1}{n}\right)}{2!}\left(\frac{\sigma R}{q L}\right)^2 - \frac{1\left(1 - \frac{1}{n}\right)\left(1 - \frac{2}{n}\right)}{3!}\left(\frac{\sigma R}{q L}\right)^3 + \ldots$$

and in the limit, when n is made indefinitely large, we have:

$$\lim_{n \to \infty} \left(1 - \frac{\gamma}{a}\right)^n = 1 - \frac{\sigma R}{q L} + \left(\frac{\sigma R}{q L}\right)^2 \frac{1}{2!} - \left(\frac{\sigma R}{q L}\right)^3 \cdot \frac{1}{3!} + \ldots$$

$$= e^{-\frac{\sigma R}{q L}} = e^{-\frac{\sigma (T_1 - T_2)}{q L}}$$

or

$$W = Q\left(1 - e^{\lambda (T_1 - T_2)}\right)$$

as before. (See equation 8, page 594 *ante*.)

Example (2)

Let us now take a numerical example, and first work out the maximum possible economy in a given case, for different final feed-water temperatures. Suppose that the steam conditions are, as before:

Dry saturated steam at the stop-valve, at 565·6 lb./in.², *i.e.*, a saturation temperature of 250 deg. C. = 482 deg. F.

Exhaust vacuum = 29 in. of mercury (bar. = 30 in.), *i.e.*, T_2 = 26·4 deg. C.

Then, if T be the final feed-water temperature, we have:—

The efficiency =

$$\frac{Q\sigma\left(T_1 - T_2 - T_2 \log_e \frac{T_1}{T_2}\right) + Q L_1\left(1 - \frac{T_2}{T_1}\right) - Q\sigma\left(T - T_2 - T_2 \log_e \frac{T}{T_2}\right)}{Q L_1 + Q\sigma(T_1 - T_2) - Q\sigma(T - T_2)}$$

That is, the efficiency =

$$\frac{\sigma\left(T_1 - T - T_2 \log_e \frac{T_1}{T}\right) + L_1\left(1 - \frac{T_2}{T_1}\right)}{L_1 + \sigma(T_1 - T)} \quad (17)$$

Now L_1 = 421 calories Centigrade, whilst σ may be taken as unity. Then we have the results given in Table V, page 628.

We thus see that the theoretical gain, if the feed water is heated right up to the boiler temperature, by tapping off steam from the turbine by infinite stages, is no less than 17·1 per cent., whilst even if we only heat it up to 127 deg. C. = 260·6 deg. F., the gain is 11·7 per cent.

Section (4).

The Case with Superheat.—Where there is initial superheat in the steam, we notice in the first place, that the highest temperature to which it is theoretically economical to heat up the feed water by tapping-off steam from the turbine, is that temperature corresponding to the pressure of the steam in the turbine, where the initial superheat has just disappeared. If it be attempted to heat the feed water above this temperature (by tapping off steam from the turbine), superheated steam will be tapped off. The result will be that this steam will be cooled down to the saturation temperature, in which case the thermodynamic loss will be considerable.

Assuming, for the sake of simplicity of argument, that the expansion in the turbine is isentropic, we can, by means of the Callendar chart, draw up a table showing the pressure at which the steam becomes saturated, and the corresponding temperature, taking the same stop-valve pressure and vacuum as before. See Table VI, page 628.

Owing to the fact that the specific heat of superheated steam is not constant, it is necessary to use the chart and the tables in order to obtain the total available heat per pound of steam, and the total heat per pound. We may then write the efficiency:

$$\text{Eff} = \frac{H_a - \sigma\left(T - T_2 - T_2 \log_e \frac{T}{T_2}\right) \ldots}{H_0 - t} = \frac{H_a - \Omega}{H_0 - t} \quad . \quad . \quad . \quad (18)$$

if Ω = work lost by tapping off, in heat units.

where t is the final feed-water temperature, H_a the total available heat per pound, and $H_0 - t$ is the total heat per pound above final feed-water temperature.

Example (3).

Remembering, then, that the feed water is to be heated in each case up to the temperature corresponding to the pressure in the turbine where the steam becomes just saturated, we may continue the calculation for the resulting efficiency as shown in Table VII, page 628.

This calculation shows that the resulting efficiency remains very nearly constant (that is, the theoretical value). If a more moderate initial steam pressure be chosen, say 225 lb./in.² absolute, a similar calculation will show the same theoretical result, the efficiency being about 0·37. Hence a very high initial superheat gives us no theoretical advantage. Actually, of course, there is a decided gain, as is well known.

Example (4).

But let us now take a case of given initial superheat, initial steam pressure, and vacuum, and calculate the maximum theoretical efficiency with varying final feed-water temperature.

Let the stop valve pressure be 225 lb./in.² absolute,

Stop valve temperature, 350 deg. C. (662 deg. F.) = 270 deg. F. superheat.

Exhaust vacuum, 29 in. mercury (26·4 deg. C.)

TABLE V.

T_1	Assumed T	T_2	$\text{Log}_e \frac{T_1}{T}$	$\frac{T_2}{T_1}$	$1 - \frac{T_2}{T_1}$	$T_1 - T$	$L_1\left(1 - \frac{T_2}{T_1}\right)$	Efficiency.
deg. C. abs.	deg. C. abs.	deg. C. abs.						
523	523·0	299·4	0·0	0·57	0·43	0·0	181	0·43
523	500·0	299·4	0·0468	0·57	0·43	23·0	181	0·4275
523	400·0	299·4	0·2700	0·57	0·43	123·0	181	0·410
523	299·4	299·4	0·5625	0·57	0·43	223·6	181	0·367

TABLE VI.

Initial superheat.		Total temperature.		Saturation point. Temperature.		Saturation point—lbs./in.²	Total available heat H_s.	Available H_s to saturation point.
deg. C.	deg. F.	deg. C.	deg. F.	deg. C.	deg. F.	Pressure (abs.)	Cal.-cent.	Cal.-cent.
0	0	250	482	250·0	482	565·6	242·5	0
50	90	300	572	206·7	404	265·0	255·8	40
100	180	350	662	180·0	356	141·0	271·1	78
150	270	400	752	157·0	315	82·0	286·5	112

TABLE VII.

T_2	T	$T - T_2$	$\frac{T}{T_2}$	$\log_e \frac{T}{T_2}$	$T_2 \text{Log}_e \frac{T}{T_2}$	Ω	$H_s - \Omega$	H_s	$H_s - T$	Eff. $\left(\frac{H_s - \Omega}{H_s - t}\right)$
deg. C. abs.	deg. C. abs.	deg. C.				cal. C.	cal. C.			
299·4	523·0	223·6	1·75	0·5596	167·5	56·1	186·4	681·0	431·0	0·431
299·4	479·7	180·3	1·60	0·4700	140·5	39·8	216·0	712·0	505·3	0·429
299·4	453·0	153·6	1·515	0·4153	124·3	29·3	241·8	743·0	563·0	0·429
299·4	450·0	150·6	1·488	0·3632	108·5	22·1	264·4	771·5	614·5	0·429

TABLE VIII.

t_2	t	$t - t_2$	$\frac{T}{T_2}$	$\text{Log}_e \frac{T}{T_2}$	$T_2 \text{Log}_e \frac{T}{T_2}$	Ω	$H_s - \Omega$	H_s	$H_s - t$	Efficiency $= \frac{H_s - \Omega}{H_s - t}$
deg. C.	deg. C.					cal. C.				
26·4	26·4	0·0	1·00	0·00	0·00	0·00	248·50	754	727·6	0·341
26·4	50·0	23·6	1·08	0·0769	22·95	0·65	247·85	754	704·0	0·352
26·4	75·0	48·6	1·163	0·1510	45·25	0·35	245·15	754	679·0	0·363
26·4	100·0	73·6	1·244	0·2183	65·3	8·30	240·20	754	654·0	0·367
26·4	122·5	96·1	1·322	0·2715	81·5	14·60	233·90	754	631·5	0·369

Then, with isentropic expansion, the saturation point is reached when the steam pressure is about 32 lb./in.² absolute, the corresponding temperature being 122·5 deg. C. (252·5 deg. F.). This is therefore the highest profitable feed-water temperature to be reached by the tap-off method. We thus obtain the figures given in Table VIII, above.

We see that the total gain, if the feed-water is heated up to 122·5 deg. C., is theoretically 8·2 per cent.

Section (5). Practical Case.

As a final example, let us take a practical case, where there are only two feed-water heaters. Let the steam conditions be the same as in the last example, that is 225 lb./in.² S.V.P. absolute,

150 deg. C. initial superheat (270 deg. F.), *i.e.*, a total temperature of 662 deg. F.

Exhaust vacuum, 29 in. mercury (bar.=30 in.).

Let the turbine overall hydraulic efficiency ratio be 0·80, in which case, assuming as before expansion with thermal equilibrium, the saturation point is reached when the steam pressure has fallen to about 17 lb./in.² absolute, the corresponding temperature being 104·5 deg. C. This is therefore the final feed-water temperature at the exit from the second heater.

If the temperature-range is the same in the two heaters, and if S be the total steam to be tapped off, then we have:

$$S = x_1 + x_2 = \frac{Q\gamma}{a}\left\{1 + \left(1 - \frac{\gamma}{a}\right)\right\} \quad . \quad . \quad (19)$$

where $a = q\,L$, and

$$\gamma = \frac{\sigma R}{n} = \frac{104{\cdot}5 - t_n}{2} \quad . \quad . \quad . \quad (20)$$

whilst the temperature at the exit from the first heater is:

$$\frac{104{\cdot}5 + t_n}{2} \quad . \quad . \quad . \quad . \quad . \quad (20A)$$

To find the value of t_n, we may, as a first approximation, write:

$$\sigma\,(x_1 + x_2)\left\{\frac{104{\cdot}5 - t_n}{2}\right\} = \sigma\,Q\,(t_n - 26{\cdot}4) \quad (21)$$

that is, writing Q in place of

$$Q - (x_1 + x_2)\text{; (see (15)).}$$

Combining (19) and (20), we obtain:

$$S = x_1 + x_2 = \frac{Q\,\sigma}{q\,L}\left(\frac{104{\cdot}5 - t_n}{2}\right)\left\{1 + \left(1 - \frac{\sigma}{q\,L}\left(\frac{104{\cdot}5 - t_n}{2}\right)\right)\right\} \quad (22)$$

Combining (21) and (22) we obtain:

$$\frac{\sigma\,Q\,\sigma}{q\,L}\left(\frac{104{\cdot}5 - t_n}{2}\right)\left\{1 + \left(1 - \frac{\sigma}{q\,L}\left(\frac{104{\cdot}5 - t_n}{2}\right)\right)\right\}\left(\frac{104{\cdot}5 - t_n}{2}\right) = \sigma\,Q\,\left(t_n - 26{\cdot}4\right) \quad (23)$$

which leads to the equation

$$t_n^3 + 1{,}560\,t_n^2 - 2{,}100{,}000\,t_n + 66{,}000{,}000 = 0 \quad (24)$$

of which the real root is

$$t_n = 32{\cdot}4 \text{ (deg. C.)}$$

so that $(t_n - t_2) = (32{\cdot}4 - 26{\cdot}4) = 6$ deg. C difference. Actually, it will be a little more, on account of our approximation in equation (21).

We can now determine the quantity of steam to be tapped off at each heater; for we have:—

$$\gamma = \frac{\sigma R}{n} = \frac{1\,(104{\cdot}5 - 32{\cdot}4)}{2} = 36{\cdot}05,$$

and

$$\frac{S}{Q} = \frac{x_1 + x_2}{Q} = \frac{\gamma}{a}\left\{1 + \left(1 - \frac{\gamma}{a}\right)\right\}$$

Now

$$\frac{\gamma}{a} = \frac{36{\cdot}05}{537} = 0{\cdot}0672$$

hence

$$\frac{S}{Q} = 0{\cdot}0672\,\{1 + 1 - 0{\cdot}0672\} = 0{\cdot}130$$

i.e., the total steam to be tapped off is 13 per cent. of Q, the total steam consumption of the turbine; also

$$\frac{x_1}{Q} = \frac{\gamma}{a} = 0{\cdot}0672,$$

i.e., at the second (highest) feed heater, we must tap off 6·72 per cent. of Q, and at the first heater 6·28 per cent. of Q.

We note that x_1 is greater than x_2 because in the high-temperature (second) heater, only the latent heat of the steam can be utilised. The sensible heat of this steam is given up (partially) in the low temperature heater.

We have now to determine the loss of output from the turbine, due to tapping off steam.

At exit from the low-temperature heater, the temperature is, by equation (20A):

$$t' = \frac{32{\cdot}4 + 104{\cdot}5}{2} = 68{\cdot}45 \text{ deg. C. (155 deg. F.).}$$

whilst the corresponding steam pressure is about 4·2 lb./in.² absolute.

The available heat remaining in the steam that has been tapped off (h_s), is given in the following table for the two heaters:—

t at heater exit.	p	$\Omega = h_s$.
deg. C.	abs.	cal. cent.
104·5	17·0	96·5
68·45	4·2	49·0

So that the resulting efficiency, if the boiler thermal efficiency be taken as = 80 per cent., is given by the equation:

$$\epsilon = \frac{\{H_s - (\Omega_1 + \Omega_2)\}\,0.8}{(H_s - T)\,/\,0.8} = \frac{0.64\,\{248.5 - (0.0672 \times 96.5) - (0.0628 \times 49.0)\}}{(754 - 104.5)} = \frac{152}{649.5} = 0.2345$$

The theoretical maximum efficiency, assuming:—

(1) 80 per cent. boiler efficiency,

(2) Expansion with 80 per cent. overall blade efficiency, and

(3) Feed-water heating by infinite stages up to the saturation temperature of 104·5 deg. C. (220 deg. F.),

works out, by the method already given, to 0·2375; whereas, without any feed water heating by the tap-off method at all, the efficiency is only 0·219; the boiler plant in this case having to supply all the sensible heat.

We thus have:—

Extent of Feed-Water Heating by the Tap-Off Method.	Number of Heaters.	Boiler Thermal Efficiency.	Turbine Blading Efficiency (Over-All)	Thermo-Dynamic Efficiency.	Gain.
deg. C.		per cent.	per cent.		p.c.
None	None	80	80	0.219	—
104·5	Two	80	80	0.2345	7·1
104·5	Infinite.	80	80	0.2375	8·5

This calculation, although only approximate, indicates that the gain in thermodynamic efficiency, when only two heaters are employed, is only about 1½ per cent. less than that theoretically attainable (in this particular case)—a rather encouraging result. In any case, the economy is so marked that the extra complication caused by the installation of a few feed-water heaters should be amply justified.

In any actual design, of course, where tap-off feed-water heaters are contemplated, the thermal efficiency of the latter must be considered, and the resulting boiler thermal efficiency must be carefully taken into account, depending as it does on the final temperature of the flue gases as they enter the stack. This temperature can be reduced by:

(1) Passing the hot flue gases through feed-water economisers, or

(2) Using them in an air regenerator for the boiler furnace.

A good compromise is to heat up the feed water by the tap-off method to, say, 93 deg. C. (200 deg. F.), and do the rest by means of the economiser.

The sacrifice in boiler thermal efficiency is then very small, especially if an air regenerator is also used.

The point is, that it is possible to so design the plant that a slight sacrifice of boiler thermal efficiency is quite out-balanced by the gain in thermodynamic efficiency, so that fuel economy is realised. In other words, we can obtain the same output from less coal.

PULVERISED COAL AS FUEL.

By Lawford H. Fry, M. Inst. C.E.

The use of pulverised coal as fuel is a branch of combustion engineering which has developed rapidly in the last few years. Further progress and an ever-widening range of application are bound to come in the future. Applied in the first instance in cement kilns, which offer particularly favourable conditions for its use, pulverised coal has since

been widely and successfully used in metallurgical heating furnaces; it has made some progress as a fuel for melting steel in open-hearth furnaces, has been tried on locomotives and in blast furnaces, and in recent installations has given remarkably efficient and satisfactory results under stationary boilers. It is not a panacea for all heating problems, but under conditions to which it is suited, the high efficiency of cumbustion and the low cost of labour of handling coal and ashes, make for economy.

There has been a tendency in the past to surround the use of pulverised coal with a certain amount of mystery and to advocate certain special appliances as vital to success. The purpose of the present article is to survey briefly the principles involved and to show that common sense and a recognition of these principles are more important than adherence to any special type of installation.

Before considering in detail the special problems presented by the combustion of powdered coal, it may be well to compare in general terms powdered coal and the fuels with which it competes, viz., hand or stoker-fired coal, natural gas, producer gas, and oil. In this comparison attention is directed to the relative commercial efficiencies of the fuels. That is to say we are concerned here not only with the number of heat units developed per pound of fuel, but rather with the number of heat units developed per unit of total cost, including first cost, cost of firing, and cost of handling ashes. The relative first cost of coal and oil, the relation between this cost and the cost of labour for firing coal and removing ashes, the cost of power for pulverising, are all factors which have an influence in deciding whether it is desirable to use pulverised coal for fuel.

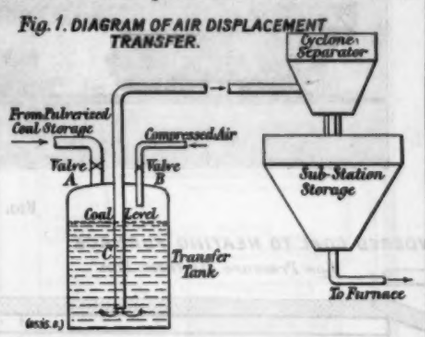
Compared with hand-fired coal, pulverised coal will show a higher efficiency of combustion, giving the same quantity of useful heat with at least 30 per cent. less coal, and where the amount of coal used is sufficient—say in a works using 200 tons or over per week—the saving in labour for handling and firing the coal, for cleaning fires and for handling ashes will in itself offset the cost of pulverising and pay interest and depreciation on the necessary machinery, together with a handsome profit. Compared with stoker firing, pulverised coal will show an economy in coal of which the amount will depend on the local conditions, and will eliminate the cleaning of fires and handling of ashes, while the ease with which firing can be started and stopped, and the possibility of running continuously without stoppages for cleaning fires give a greater flexibility of operation.

Where natural gas is abundant and cheap, as, for example, was the case a few years ago in the Pittsburg district of Pennsylvania, powdered coal will hardly be able to compete with this clean, easily handled, smokeless fuel of high heating value. In Pittsburg to-day, however, with a continual increase in consumption and a relative decrease in the output of gas, pulverised coal is coming into prominence. Where oil is available the choice as to fuel between oil and pulverised coal will be determined almost entirely by the relative cost of oil and coal. At equal cost per heat unit the oil would have the advantages of greater ease in handling, of burning without dust, and of avoiding the expense of the pulverising installation. The two fuels burn with approximately the same efficiency, and as a rough basis of comparison it may be taken that a gallon of fuel oil is equivalent to 10 lb. or 12 lb. of pulverised coal. It should be noted that an equal price per heat unit will only be found where oil is relatively cheap and coal relatively expensive. For example, under present conditions in central Pennsylvania, with oil costing over 10 cents per gallon and coal, say, 6·50 dols. per gross ton pulverised, the cost per 100,000 British thermal units will be, say, 6·6 cents for oil and 2·2 cents for coal. That is to say, it will cost three times as much to burn oil as to burn powdered coal. Under these conditions oil can only compete with pulverised coal where the furnace conditions are such as to make the ash content of the coal a serious disadvantage. For example: Open-hearth furnaces with regenerator chambers which trap the ash, or heat treatment furnaces of the muffle or semi-muffle type which also offer pockets liable to become clogged. This question will be referred to again later on.

A comparison between producer gas and powdered coal can hardly be made accurately in general terms. The first cost of installation of gas-producer house and pulverising plant will not differ greatly. The power and labour cost of gasifying and of pulverising will be approximately the same. Fuel cost will be slightly in favour of the pulverised coal with an added advantage in the wider range of coal which can be used. There will be a small extra amount of power required or the distribution of the coal from the pulverising plant to the furnaces, but this is more than offset by the first cost of regenerators for the furnaces, and the consequent cost of maintenance and complication in operation. It is probable that where producers are in operation they will hardly be displaced by pulverised coal, but in a new installation the possibility of effecting economies by the use of pulverised coal should be considered before deciding on producer gas.

Before going from the general to the particular a word as to safety may be said. It is not unusual to hear those unfamiliar with pulverised coal offer as an objection to its use the fact that it may cause an explosion. There have been destructive explosions of pulverised coal, and its use as a fuel calls for certain precautions. The same is true

Fig. 1. DIAGRAM OF AIR DISPLACEMENT TRANSFER.



of both oil and gas, which are not rated as unusual hazards. The three fuels stand on practically equal terms in this respect. Neither oil, gas nor coal is an explosive *per se*. If oil vapour, gas or finely-pulverised coal be mixed with the amount of air necessary for combustion, the mixture will ignite readily and burn almost instantaneously. Consequently in a confined space the effect will be explosive. The precautions taken with oil and gas to avoid danger from this cause will be equally effective with pulverised coal.

Coming to a more detailed survey of the problems, these will be found divisible into three groups, under the headings Pulverising, Transportation of Pulverised Coal, and Combustion.

Pulverising.—This offers no novel problem. The standard fineness is 85 per cent. through a mesh of 200 to the inch, and 95 per cent. through 100 to the inch, with possibly a higher degree of fineness where specially close control of the heating is required. A number of standard types of mill are available, good results being obtained with roller, ball and tube mills. A convenient lay-out of a pulverising plant with roller mill is as follows: A track hopper is provided so that the incoming coal is dumped directly from car to hopper. In a particular plant dealt with in more detail below, the mill has a capacity of 4½ tons per hour, and the hopper has sufficient capacity to take the load of a 50-ton drop-bottom car. From the hopper the coal is fed automatically through a crusher breaking to 1½-in. cubes, past a magnetic separator to the dryer. Local conditions may make it desirable to have a crushed coal storage placed ahead of the dryer, particularly if several mills of the above capacity, instead of only one, are to be fed from the one track hopper. With a 4½-ton mill, a 50-ton hopper and facilities for a free movement of cars, further storage is unnecessary. From the dryer the coal, with its moisture reduced to about one-half of 1 per cent., goes to the mill, and after pulverising is lifted by air to the pulverised coal storage tank, which, in the typical installation taken, has a capacity of 50 tons. The transfer of the coal from the storage bin to the furnace offers for consideration certain devices which are individual to the use of pulverised coal as fuel.

Transportation.—Four main methods of transport or transfer are in use, namely, screw conveyors, air flotation, air displacement, and pumps. The screw conveyor is the most obvious method of transfer and has been in use longest. It is excellent where the coal is to be transferred in a straight line for a comparatively short distance, but at each change in direction the coal has to be transferred from one conveyor to another, while a change of level requires a bucket elevator. This introduces complication. To handle say, 4 tons of coal an hour, the screw conveyor would be approximately 6 in. in diameter, while the power required would be about 2½ h.p. per 100 ft. of conveyor. A conveyor of this size requires to be rigidly supported, and in case it is to be introduced in an existing building, additional supports will probably be required. It is usual to arrange a walk-way along the top of the conveyor so that it may be inspected readily. Compared with a long screw conveyor an air flotation distributing system has the advantage of lighter loads to be carried by the building and of keeping all moving mechanical parts at one point for each system, so that maintenance is simplified. As developed by Holbeck this method of transport has been widely used for distributing coal to a number of furnaces in a single shop, or in a concentrated group of shops, and has given excellent results. A typical example is a shop manufacturing wrought steel wheels, having 10 furnaces with a total consumption of abour 4 tons of coal per hour. The distributing system consists of a constant-pressure distributing fan with a capacity of 20,000 cub. ft. of air per minute, maintaining air circulation in a pipe system running around the walls of the shop, which is 200 ft. long by 120 ft. wide.

The diameter of the pipe is 20 in. at the delivery of the fan, and is reduced in successive stages after passing each group of furnaces, to 11 in. at the completion of the circuit. At this point the coal, which has not been taken by the furnaces is returned through a cyclone separator to the storage bin. The fan which delivers air at about 8-oz. pressure is driven by a 75-h.p. motor. The pulverised coal is fed into the air circuit close to the delivery of the fan, by a screw conveyor taking coal from the main storage tank, and driven by a variable-speed motor. In the most recent installations the speed of the coal feed screw is automatically controlled by a regulator operated by the air flow, so as to maintain a fairly constant ratio between the quantity of air and the quantity of coal. It will be understood that for each burner a branch pipe is tapped into the main circuit with a valve to control the amount of coal and air mixture taken. It follows that the amount of air delivered by the fan to maintain a constant pressure, depends on the number of burners in operation, and with automatic regulation the amount of coal fed into the system is dependent on the amount of air being circulated. When this type of air flotation was introduced it was thought that the coal and air could be maintained intimately mixed so that combustion could be maintained with a small amount of secondary air taken in by induction round the burners. In practice, however, it was found that the mixture of coal and air did not remain uniform throughout the distribution system, and consequently a positive supply of secondary air at low pressure was added. This gives independent control of both coal and air supply, and permits accurate regulation of the combustion conditions.

While the air flotation system is well adapted to the distribution of the coal to a compact group of furnaces within a comparatively short radius, the air displacement system or a pump is to be preferred when the coal has to be transferred from the pulverising point to a group of furnaces lying at a distance of, say, from 500 ft. to 3,000 ft. The principle of the air displacement system is illustrated diagrammatically in Fig. 1. The pulverised coal is delivered from the storage tank by screw conveyor or gravity to the transfer tank through the valve A, the compressed air valve B being closed. The weight of coal introduced is con-

veniently measured by carrying the transfer tank on a platform scale. When the tank contains the desired amount of coal, the valve A is closed, and air at a pressure of 80 lb. to 100 lb. per square inch admitted through the valve B. This forces the coal up through the pipe C and out to the delivery point, where the air escapes through a cyclone separator and the coal falls by gravity into a storage tank. From this sub-station it is delivered to the furnaces by screw conveyor or air flotation. In some installations the coal is distributed to bins at the furnaces by this system. With a transfer tank to hold 3,000 lb. of coal this quantity can be delivered through a 3-in. wrought-iron pipe up to a distance of 3,000 ft., about 5 minutes being required to empty the transfer tank. The volume of air required is that required to displace the coal in the transfer tank.

As an alternative to the air displacement system for transportation, the Kenyon pump has been introduced recently. The coal is put under pressure by a screw in the barrel of the pump, while at the outlet from the barrel a small quantity of compressed air is admitted. This is not done to increase the pump pressure, but merely to dilute the coal and give greater fluidity. A pump designed to deliver 8,000 lb. of coal per hour a distance of 1,200 ft., through a pipe 3 in. in diameter, is driven by a 15-h.p. motor, while air at 80 lb. per square inch is admitted at the rate of about 10 cub. ft. of air per pound of coal. Several pumps are now in service, and if the results in continued service do not belie present indications, this pump will be a valuable addition to existing methods of coal transportation.

The four systems of coal transfer described above are such as will ordinarily be used, either singly or in combination, in a permanent installation for the distribution of coal throughout a works. The slide at the base of the suspended bin is opened and the pulverised coal allowed to run out into the stationary reservoir. The empty bin is replaced on the car and returned to be re-filled. To deliver the coal from the stationary bin to the furnace an ejector or siphon operated by air at 80 lb. per square inch is used, the arrangement being as shown in Fig. 3, and the distance between bin and furnace varying from 5 ft. to 50 ft. The siphon delivers the coal into a pipe which supplies air at a pressure of about 8 ounces. The whole arrangement is extremely simple and yet entirely effective.

Combustion.—Coming first in position but last in importance under this head, is the burner. The number of patents on pulverised coal burners to be chosen for delivering the coal in regulated quantity into the air current will depend to a certain extent on the method of transportation from mill to furnace. In the case of coal transportation by air flotation to the furnace, the coal delivery pipe draws directly from the main circulation pipe and the rate of supply is controlled by a plug valve. If the coal is delivered by air displacement, pump, or screw conveyor, from the mill into a bin near the furnace, the feed from bin to furnace can be made by air siphon as in Fig. 3, or by screw feeder in which the amount delivered can be controlled by variable speed or by a by-pass arrangement. The air siphon will have preference where the bin must be placed some distance from

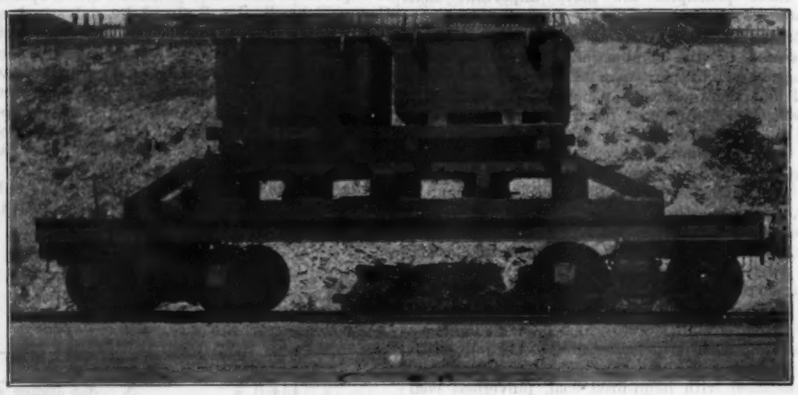


Fig. 2.

Fig. 3. METHOD OF APPLYING POWDERED COAL TO HEATING FURNACE.

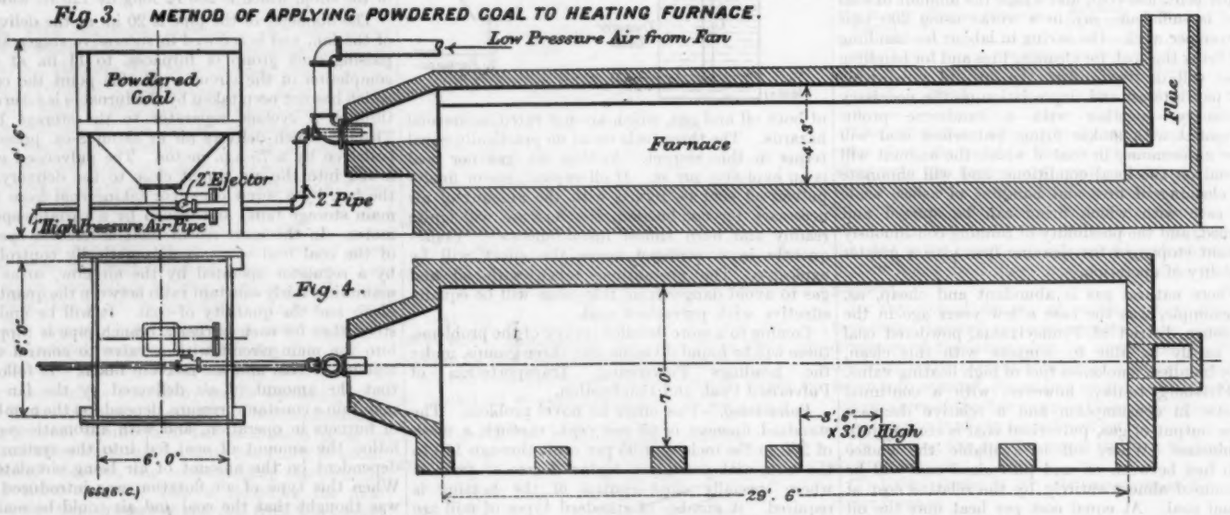


Fig. 4.

Where, however, an insolated furnace or group of furnaces is to be supplied with coal at a considerable distance from the pulverising plant a car similar to that shown in Fig. 2 may be found useful. This car was suggested by the writer, and has been in successful operation for nearly two years at the plant of the Standard Steel Works Company, Burnham, Pa. It was put into service, because, pending the construction of a second pulverising plant there was a surplus of coal at one end of the plant, and an opportunity for its use at the other end, about a mile away. The car carries two cast steel bins, holding about 4,000 lb. of coal each. The base of each bin is an inverted pyramid tapering from a section 6 ft. square to an opening 12 in. square closed by a slide. Loosely-fitted wooden covers sheathed with tin, to shed rain, are provided. The bins are filled by gravity, from spouts on the pulverised coal storage bin, and on arrival at the delivery point a bin is lifted from the car by a travelling crane, using the lifting eyes seen at the upper corners of the bin, and held above the stationary bin or reservoir shown in Figs. 3 and 4. is legion, but it will be found that a very large number of them represent ingenuity applied to overcoming difficulties which in point of fact do not exist. The only essential requirement of a pulverised coal burner is that the coal shall be fed at a controllable rate into a current of low-pressure air directed into the furnace. In Figs. 3 and 4, for example, the coal is delivered by an air siphon into the delivery pipe from a fan which furnishes the bulk of air for combustion. This arrangement is subject to wide variations, in the manner of delivery of both the air for combustion and the coal. The air for combustion may be furnished entirely by the current carrying the coal, or some may be taken in by induction around the current carrying the coal, or again, as in the case of the stationary boiler shown in Fig. 5, page 631, the bulk of the combustion air may be taken in by the furnace draught through independent openings.

So far as the coal delivery is concerned, the current of air into which the coal is delivered at a measured rate requires only sufficient volume to carry the coal into the combustion chamber. The method the furnace or if the space near the furnace does not allow the bin to be placed above the furnace level. Where possible, however, the bin should be placed so that coal can be delivered direct to the air pipe at the furnace by gravity and a screw feeder, as this gives closer and more uniform regulation of the coal supply than can be obtained with the air siphon. When the coal is brought to the furnace by air, either from a siphon or from a flotation system, it is desirable to have the coal delivery pipe concentric with, and parallel to, the secondary air supply pipe as indicated in Fig. 3, while coal from a screw feeder is best delivered vertically downwards into the horizontal air pipe a short distance back from the entrance to the furnace.

Combustion within the furnace can be very accurately controlled by regulating the velocity and method of introducing the secondary air. It is possible by introducing a full volume of air at low velocity to concentrate combustion near the entrance point, or by distributing the air supply to extend the combustion zone throughout the length of the furnace. As an example of the latter con-

dition stands the case of a furnace having a cross-section of about 18 in. square and a length of 25 ft., heating rods for a spike-making machine. With a single burner introducing coal and some air at one end, and additional air supply at two points along the furnace, the temperature is maintained uniform throughout the length of the furnace.

The combustion of the coal in the furnace is differentiated sharply from that of either oil or gas by the fact that the coal carries a certain proportion of incombustible solid, the amount varying with the ash content of the coal. As the temperature of combustion is above the fusing point of the ash, the flame carries a spray of minute molten particles of ash, which will adhere to any surface with which they come in contact. The roof and flues of a metallurgical furnace burning pulverised coal will be seen to be encrusted with stalactites and stalagmites built up out of the ash, and if the furnace design and conditions of operation bring too large an amount of molten ash into contact with the flue walls the flue may be entirely closed after a short run. This action makes it impracticable to apply powdered coal to a stationary boiler successfully without a complete re-design of furnace. It is essential to provide a long flame-way so that combustion may be completed and the ash particles cooled below the temperature at which they are plastic, before they come in contact with the boiler or flue surfaces. It is, of course, essential if the boiler is to be efficient that combustion shall have been completed before cooling of the products of combustion is carried out, and that the cooling shall take place by radiation to the evaporative surface of the boiler, and not by transfer of heat to brick-work or exterior surfaces.

A boiler installation which is giving excellent results is illustrated in Fig. 5, which is taken from a paper presented to the Fuel Conservation Section of the Railroad Administration, by Mr. John Anderson, chief engineer of power plants, Milwaukee Electric Railway and Light Company. The boiler is a three-pass Edgemoor water-tube boiler of 468 rated horse-power, with a furnace approximately 15 ft. high by 10 ft. wide, and 12 ft. from front to back. The coal is fed vertically downwards through the top of the furnace by a Lopulco burner. A small amount of air at 6 ounces pressure comes in with the coal, the bulk of the air combustion entering through openings in the front of the furnace. On a test run this boiler, operating at 117 per cent. of its rated power, gave an evaporation equal to 85 per cent. of the heat in the coal fired. The successful operation is due to the large volume and to the arrangement of the combustion space. As first installed the furnace was considerably less than 15 ft. in height, and much trouble was experienced with the molten ash "honeycombing" on the flues. Even with the deepened furnace the same trouble is still encountered if the draught at the breeching is increased from its normal value of 0·1 in. to 0·2 in. of water, thus short-circuiting the flow of fuel during combustion. In a furnace of this type a very small proportion of the ash in the coal collects at the bottom of the furnace in the form of nodules of slag. The bulk of the ash is carried out through the stack as an impalpable dust. This dust is so finely divided as a result of the grinding and the disintegrating action of combustion, that it can be distributed through a chimney in the centre of a metropolitan area without causing inconvenience or comment. In boiler operation frequent blowing of the dust from the flues is necessary if high efficiency is to be maintained. In open-hearth or other furnaces with regenerators the dust is a serious inconvenience, as the large area and consequent low velocity of gas in the regenerator chambers allows the dust to settle. Even more trouble will be experienced if the ash reaches the regenerators in its plastic condition. Similar difficulties are presented by the use of pulverised coal in muffle or semi-muffle furnaces.

While the fact that the ash is intimately associated with the combustible leads to a certain amount of inconvenience in boiler and regenerator furnaces, it is probable that the presence of the ash in a metallurgical furnace has certain advantages and is responsible for the fact that the heat obtained with powdered coal is "softer" than that given by oil. The heater will describe steel heated with oil as having "a dry brash heat," while with powdered coal "a mellow soaking heat" is obtained. It seems probable that the individual particles of oil burn at a very high temperature and that a part of the radiation starting at this temperature reaches the steel, while in the coal fire the particles form a haze which protects the steel from direct high temperature radiation, and produces a more uniform diffusion of temperature throughout the furnace.

In locomotive practice the problem of using powdered coal for fuel has not reached the point of a final solution. Several successful applications are reported, but none so conspicuous as to be the forerunners of an immediate widespread use of the fuel. The fact is that the advantages to be gained are less, while the difficulty of application is greater than in stationary boiler practice. One great

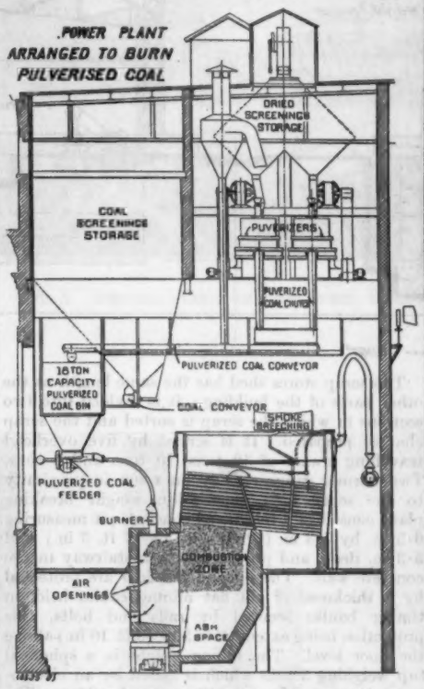


Fig. 5.

advantage offered in stationary and not in locomotive service is the reduction in labour cost secured by the mechanical handling of coal and ashes. It is true that the boiler efficiency to be obtained in a locomotive with pulverised coal may be considerably higher than that with hand-firing, but in the majority of cases this will hardly more than offset the cost of pulverising. The most probable point of entry for pulverised coal as locomotive fuel is to be found where coal of good quality is high in price, while low-grade fuel such as lignite or poor anthracite are available at low cost. In such cases it may be practicable to burn the low-grade fuel in pulverised form and effect an appreciable saving.

The technical problem of burning pulverised coal in a locomotive boiler is complicated by the necessarily restricted fire-box volume. In the case of the stationary boiler in Fig. 5, it was not difficult to provide approximately 1,800 cub. ft. for a 468-h.p. boiler, that is nearly 4 cub. ft. per horse power, while in a locomotive not more than one-twentieth of this volume is available. This is not to say that the use of pulverised coal is impracticable in locomotive service, for it must be remembered that the necessity of obtaining a large boiler horse-power in a small space has lead to forced draught and intensive combustion conditions in the locomotive. Under ordinary conditions with hand-fired coal a locomotive boiler develops a horse-power from about one-tenth the amount of heating surface usually required in stationary practice. The conditions in stationary and locomotive practice are so dissimilar that success in the former is not immediately transferable to the latter. However, it may be predicted that if the incentive is sufficiently great, which, as we have pointed out, will probably be the case only under special conditions of fuel supply, the successful use of pulverised coal in locomotives can be counted on with confidence. For the present the matter must be considered as in the experimental state, with each case presenting a novel problem for solution.

So far pulverised coal has been burnt in fire-boxes designed originally for grate firing, a change in the brick arch being depended on to adapt the box to pulverised fuel. The writer feels that a complete re-design of the locomotive boiler adapting it to the special requirements of pulverised coal, would be a most promising opportunity for progress.

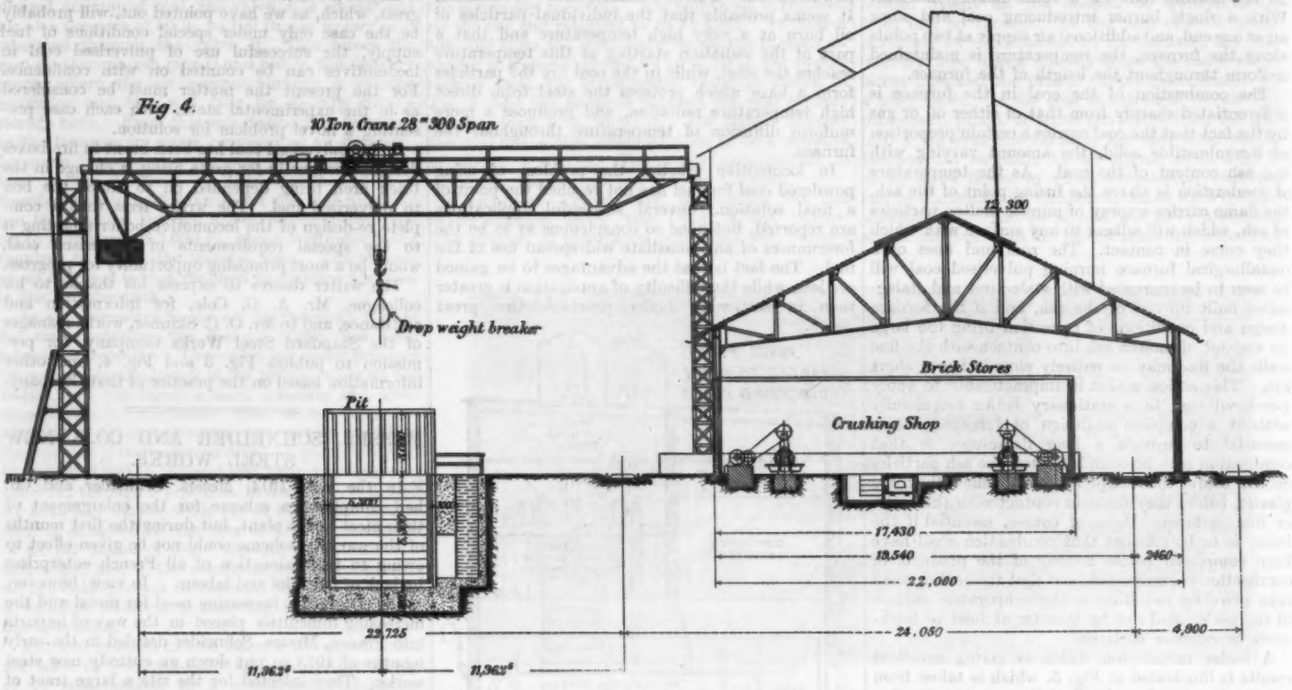
The writer desires to express his thanks to his colleague, Mr. A. G. Cole, for information and assistance, and to Mr. O. C. Skinner, works manager of the Standard Steel Works Company, for permission to publish Fig. 3 and Fig. 4, and other information based on the practice of that Company.

MESSRS. SCHNEIDER AND CO.'S NEW STEEL WORKS.

In the year 1914, Messrs. Schneider and Co. had completed a scheme for the enlargement of their steel works plant, but during the first months of the war this scheme could not be given effect to owing to the dislocation of all French enterprises by lack of material and labour. In view, however, of the constantly increasing need for metal and the increasing difficulties placed in the way of imports into France, Messrs. Schneider decided in the early months of 1915 to put down an entirely new steel works. They selected for the site a large tract of land which they purchased on the outskirts of Creusot, near the village of Le Breuil, where space is available for future extensions. One disadvantage of this tract of land was its unevenness; it had to be excavated at parts to fill in others. The filling in of the lower levels was carried out at the rate of 100 cub. m. (3,500 cub. ft.) per day and took one year to complete. The plans for the open-hearth furnace plant were got out in August, 1915. The foundation work for the new building was commenced in November of the same year on that part of the site which required no levelling. The foundations, masonry and structural work were carried out actively, and formed, together with the construction of the gas producers the subject of separate contracts. Messrs. Schneider, however, executed the major part of the installation, manufactured the iron and steel material, and erected most of the mechanical apparatus. Their Chalon yard* built the structures for the overhead travelling cranes, for the charging and conveying machines, and for the gas producers. Their Champagne works† manufactured all the electric motors and the greater part of their accessory apparatus. The first pillar was erected at the site on January 1, 1916, and the first 60-ton open-hearth furnace made its first cast on July 30 of the same year. Work on the new plant was continued without interruption, and steel production was carried out simultaneously on an increasing scale. The steel works were completed at the commencement of 1918. As they now stand, they can easily produce 250,000 tons of open-hearth steel per year; they represent the modern type of French steel works, equipped with every mechanical device for reducing manual labour to a minimum, and specially suited for the manufacture of high quality steel in large quantities. They are illustrated in Figs. 1 to 3, on Plates LXVII and LXVIII, in Fig. 4, on page 632, and in the views Figs. 5 to 8, on pages 633 and 642. They lie in a north-southerly direction, and from east to west they comprise a gas producer bay containing 28 producers, a scrap stores, the charging bay containing six open-hearth furnaces of 50 tons to 60 tons and two of 25 tons to 30 tons, the casting bay, a stripping and ingot delivery bay, an ingot and ingot mould depot. The annexes consist of a dolomite plant, a fitting and maintenance shop, a store for fireproof material, an

* See Engineering, vol. lxvi, page 417.
† See Engineering, vol. lxxviii, page 687.

MESSRS. SCHNEIDER AND CO.'S NEW STEEL WORKS, BREUIL, NEAR CREUSOT.



electric substation, a yard for the breaking up of scrap and the work's offices.

The iron building containing the gas producers is 181·5 m. (595 ft.) long by 18 m. (59 ft.) wide. It contains two sets of 14 producers each. The working platform is 3·2 m. (10 ft. 6 in.) and the upper platform 8·7 m. (28 ft. 6 in.) above the floor level. Both platforms are cut out above the coal bunker. The building is served by two overhead travelling cranes carrying grabs. The coal bunker runs along the whole length of the building on the east side and is 6 m. (19 ft. 8 in.) deep below the floor level. It can contain 5,000 tons of coal. The coal is taken by the grabs from the bunker to fill the hoppers located above the gas producers. Each hopper can contain about 35 tons of coal. The whole plant can thus contain about 6,000 tons of coal, sufficient for one month's working. Coal is supplied to the bunker from wagons which run on a track extending along the east side of the building and covered by a shed. The gas producers are 2·6 m. (8 ft. 6 in.) inside diameter. Each grate consists of a star-shaped hood having four points, able to revolve with the producer shaft so as to obtain automatic freeing of the clinker by means of a fixed plate. The soffit of the arch of each producer is 2·5 m. (8 ft. 2 in.) above the top of the hood and 3 m. (9 ft. 10 in.) above the level of the water-seal. The producer shaft is revolved in either direction by an endless screw; it can make eight complete revolutions per 24 hours, its speed being adjustable at will, and it rests on ball bearings. A second water-seal prevents the blast which is delivered to the ash-pit from escaping underneath the shaft. The producer arches are 250 mm. (9·84 in.) thick, and are made of alumina bricks; the side linings are made of the same bricks and are 295 mm. (11·6 in.) in thickness. The gas produced flows through a horizontal passage 0·7 m. (27·56 in.) inside diameter and 1 m. (39·37 in.) long into a dust collector, the inside wall of which is made with baffles. Thence it flows finally to the main collector, which is also provided with dust collectors. The blast necessary for the gas producers is supplied by four fans. In case of accident to the motors or to the electric current main, the blast can be supplied by injectors, there being one injector for each producer. Steam is supplied to the producers by a set of six boilers coupled two by two, each boiler being capable of vaporising 1,600 kg. (3,526 lb.) per hour. The producer plant is shown in the plan in Fig. 1.

The scrap stores shed has the same length as the other parts of the building; it is divided into two sections in which the scrap is sorted and the scrap charges prepared. It is served by five overhead travelling cranes of 12 tons, 10 tons and 5 tons. Two normal gauge railway lines run in proximity to the scrap bins. The falling-weight breaking plant consist of a reinforced concrete pit measuring 6·3 m. by 5·3 m. (20 ft. 8 in. by 17 ft. 5 in.) and 5·3 m. deep, and provided with a stairway in the concrete wall. The pit and the door are protected by a thickness of old flat mining cables held on timber baulks secured by rails and bolts, this protection being extended to 3 m. (9 ft. 10 in.) above the floor level. The falling weight is a spherical tup weighing 3 tons which is raised by an electro-magnet operated from the 10-ton overhead travelling crane. The height of fall is 17 m. (55 ft. 9 in.). This plant serves for breaking up wasters, the weight of which does not exceed 10 tons; it is shown in the plan Fig. 1 and in the view Fig. 6, on page 633. The falling weight breaker pit is illustrated in Fig. 4, on the present page.

The furnace charging bay has a length of 224·5 m. and a width of 25 m. (82 ft.) between the pillar centres. The longitudinal distance between the pillars is 25·5 m., except in the case of the two last, where it is 17·5 m., as in the casting bay. The overhead travelling crane track is 14 m. (46 ft.) above the floor level. The furnace charging platform has been designed for a load of 3,000 kg. per square metre (615 lb. per square foot); it is at a height of 5·6 m. (18 ft. 5 in.) above the floor level and the free space underneath it is 4·4 m. (14 ft. 5 in.) high. The longitudinal axis of the furnaces is at a distance of 4·5 m. (14 ft. 9 in.) from the centre of the west pillars and of 24·15 m. (79 ft. 3 in.) from the centre of the chimneys. The width of 25 m. for this bay was decided upon so as to allow of locating underneath the furnace platform not only the regenerators, the reversing valves, the gas outlet pipes and the dampers, but also a track the axis of which is 2·675 m. (8 ft. 9 in.) from the outside of the bay. This track allows of free delivery to the furnaces of material such as bricks, and large size bottom-iron, scrap and pig-iron which are not regularly kept in the scrap stores, it allows also the easy removal of waste material proceeding from the furnace repairs.

The open-hearth furnaces are eight in number, there being six 50-ton to 60-ton furnaces (one acid and five basic) and two 25-ton to 30-ton furnaces, both basic. The larger furnaces have five doors, three being for charging and two for following the progress of the heat; the smaller furnaces have only three charging doors. All the doors are water-jacketted. The nozzles are also water-cooled to reduce wear. The water reaches the furnaces at a pressure of 3 kg. per square centimetre (42·7 lb. per square inch). The cooling water circulates also through the main furnace uprights and is returned in part to the tanks of the gas-reversing valves. The whole of the water is ultimately collected and made to return to the works' water circuit. The reversing valves and dampers are operated by cables and counterweights so as to leave the space underneath the furnace platform completely free.

The two dampers of the regenerators and that of the chimney are operated by means of small winches. The inlet valves are worked by small shafts and hand wheels. The whole of the operating mechanism is grouped together and is located along the façade and in the rear of the chimneys; it occupies a space of 6 m. (19 ft. 8 in.) in length. Near this are also provided the chimney-pressure gauge and the reversing recording device. The gas valve has four compartments, 2·68 m. (8 ft. 9 in.) inside diameter and plates 25 mm. (0·984 in.) thick for the 50-ton to 60-ton furnaces, and 2·18 m. (7 ft. 2 in.) inside diameter and plates 22 mm. (0·866 in.) thick for the 25-ton to 30-ton furnaces. The bell is built up of two halves separated by a 35-mm. (1·378 in.) space, which allows of air cooling the middle partition. Means are provided to stop the gas inlet flow during reversing so as to save gas. The air valve is a simple butterfly valve with three openings, the central one communicating with the chimney. The gas is delivered to the furnaces by an underground flue on which is branched a horizontal collector, 1·05 m. (3 ft. 6 in.) inside diameter, 8 m. (26 ft. 3 in.) in length, having a fireproof lining 65 mm. (2·56 in.) thick and fitted at each end with two doors and two fireproof lined valves; one of these latter is an inlet valve, the other being a stop valve. The gas flows down from the collector to underneath the gas-reversing valve by a steel pipe in which a door is provided for cleaning out purposes. The air-governing valve is located between the air and gas valves, and the gas governing valve between the gas valve and the track. The regenerators are located underneath the nozzles, the space beneath the hearth being completely free. This facilitates

MESSRS. SCHNEIDER AND CO.'S NEW STEEL WORKS, BREUIL, NEAR CREUSOT.

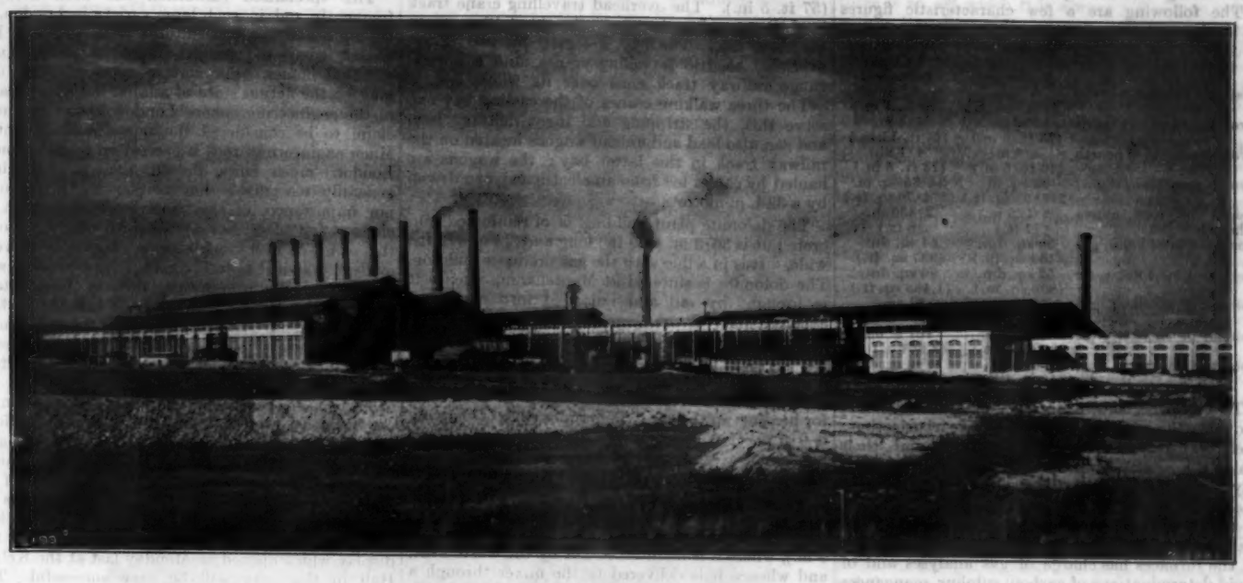


FIG. 5. GENERAL VIEW OF NEW STEEL WORKS.

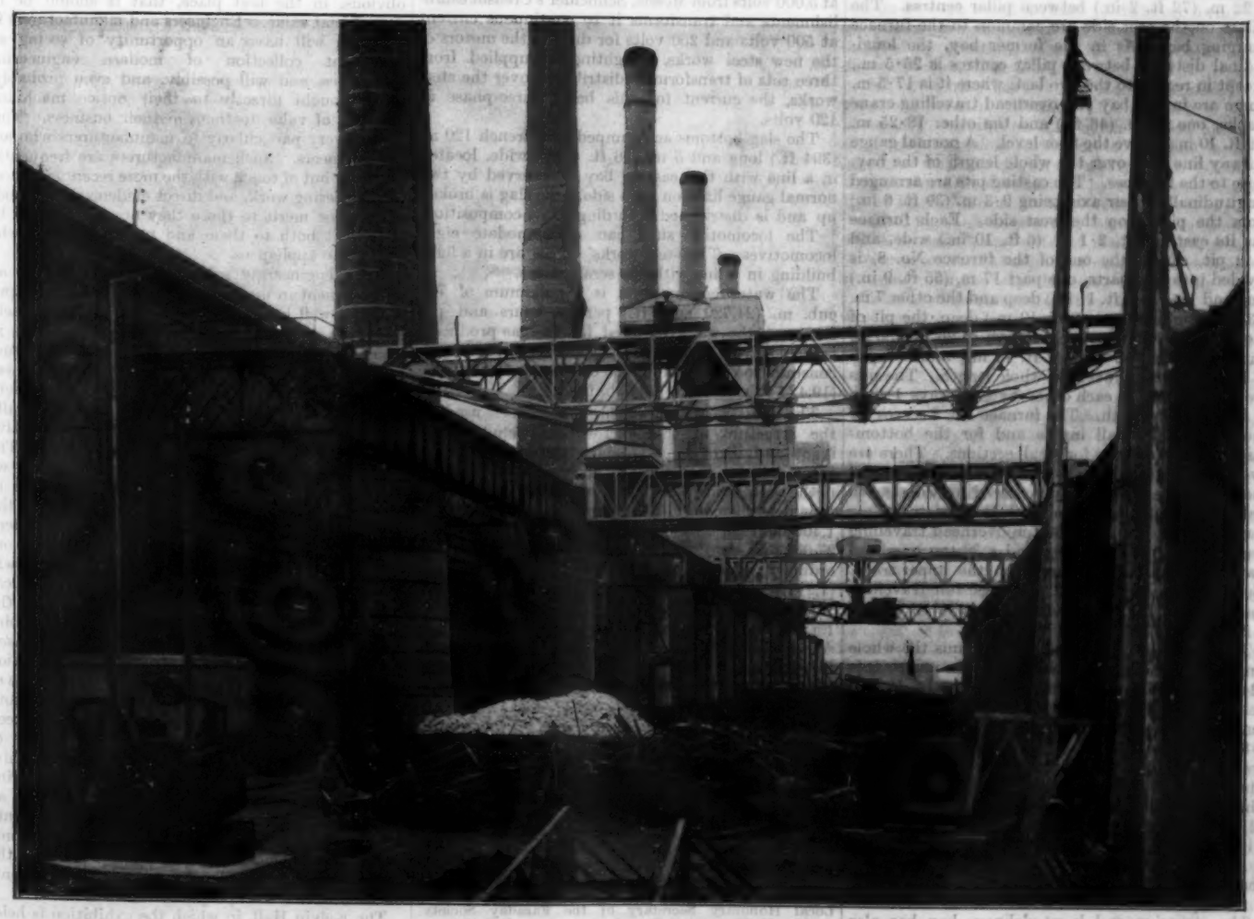


FIG. 6. SCRAP STORES.

its cooling. The location of the furnaces is shown on the plan, Fig. 1, details are illustrated in the sections Figs. 2 and 3, and views of the charging and casting sides are reproduced in Figs. 7 and 8.

The following are a few characteristic figures of the furnaces :—

	25-Ton to 30-Ton Furnaces.	50-Ton to 60-Ton Furnaces.
Distance between nozzles	8·8 m. (28 ft. 10 in.)	11 m. (36 ft. 1 in.)
Available length of hearth	7·2 m. (23 ft. 8 in.)	8·5 m. (27 ft. 11 in.)
Available width of hearth	3·2 m. (10 ft. 6 in.)	4·1 m. (13 ft. 5 in.)
Hearth area	23 sq. m. (247·57 sq. ft.)	34·85 sq. m. (374·70 sq. ft.)
Height of roof above hearth	2·125 m. (7 ft.)	2·430 m. (8 ft.)
Section of inlet holes, gas	30 sq. dm. (465 sq. in.)	54 sq. dm. (837 sq. ft.)
Section of inlet holes, air	52 sq. dm. (806 sq. in.)	96 sq. dm. (1,488 sq. ft.)
Volume of checkers, gas	52,200 c. m. (1,843 c. ft.)	82 cm. (2,896 c. ft.)
Volume of checkers, air	66,500 c. m. (2,348 c. ft.)	101 c. m. (3,567 c. ft.)
Height of checkers ...	6 m. (19 ft. 8 in.)	6 m. (19 ft. 8 in.)

Two cupolas shown in Fig. 2, Plate LXVIII, provide the metal for liquid recarburisation; their capacity is 6 tons per hour and their inside diameter 0·8 m. (31·5 in.). The charging bay is served by three 10-ton charging machines, one 40-ton overhead travelling crane having a 10-ton auxiliary crab, and one 12-ton overhead travelling crane. A laboratory in close proximity to the furnaces has charge of gas analyses and of rapid determinations of carbon, sulphur, manganese and phosphorus. Specimens from the heats are taken and hammered under three 350-kg. (770 lb.) pneumatic hammers driven by a 20-h.p. electric motor and located between the furnaces Nos. 2 and 3, 4 and 5, and 6 and 7. (See Plan, Fig. 1.)

The casting bay is 224·5 m. in length; its width is 22 m. (72 ft. 2 in.) between pillar centres. The pillars on the east side are common to the furnace charging bay. As in the former bay, the longitudinal distance between pillar centres is 25·5 m., except in regard to the two last, where it is 17·5 m. There are in this bay two overhead travelling crane tracks, one 14 m. (46 ft.) and the other 18·25 m. (59 ft. 10 in.) above the floor level. A normal gauge railway line runs over the whole length of the bay, close to the furnaces. The casting pits are arranged longitudinally, their axis being 9·3 m. (30 ft. 6 in.) from the pillars on the west side. Each furnace has its casting pit, 2·1 m. (6 ft. 10 in.) wide, and each pit, except the one of the furnace No. 8, is divided into two parts, one part 17 m. (55 ft. 9 in.) long and 1·5 m. (4 ft. 11 in.) deep and the other 7 m. (23 ft.) long and 3 m. (9 ft. 10 in.) deep, the pit of the furnace No. 8 having a length of 26 m. (85 ft. 3 in.), a width of 2·4 m. (7 ft. 10 in.) and a depth of 1 m. (3 ft. 3 in.) over its whole length. The pits are separated from each other by gangways 1·5 m. (4 ft. 11 in.) in width. The furnace No. 8 serves for the casting of small ingots and for the bottom-casting of ingot series for small sections. There are two stopper-rod drying stoves, one at each end of the bay. The casting bay is served by three 6-ton walking cranes, two overhead 100-ton travelling cranes for casting, one 80-ton overhead travelling crane, two 60-ton strippers and a 30-ton overhead travelling crane which runs upon the upper track. (See Fig. 3, Plate LXVIII.) The 80-ton travelling crane has a 15-ton, and each of the 100-ton cranes a 20-ton auxiliary crab.

The ingot and ingot mould depot runs the whole length of the buildings of which it forms part. It is 224·5 in. (736 ft.) long, 12·75 m. (41 ft. 10 in.) being the longitudinal distance between the pillar centres except at the north end, where the distance is 8·75 m. (28 ft. 9 in.). The pillars on the east side are common to the stripping and ingot delivery bay. The width between pillar centres is 25 m. (82 ft.). The overhead travelling crane track has a length of 221·5 m. (727 ft.) and is at a height of 12 m. (39 ft. 4 in.) above the floor level. The depot is served by a 12-ton overhead electric travelling crane. A normal gauge railway track runs the whole length of the depot.

The stripping and ingot delivery bay has also a length of 224·5 m.; it is 18 m. (59 ft.) wide between pillar centres. The pillars on the east side are common to the casting bay; they are 25·5 m. (83 ft. 8 in.) apart longitudinally, except in the case of the two last where the distance is only 17·5 m. (57 ft. 5 in.). The overhead travelling crane track is of the same length and at a height of 12 m. above the floor line. The bay is served by two 12-ton overhead electric travelling cranes, and a normal gauge railway track runs over its whole length.

The three walking cranes of the casting bay can serve this, the stripping and ingot delivery bay, and can also load and unload wagons located on the railway track in this latter bay; the wagons are hauled by cables led from an electric capstan driven by a 38-h.p. motor.

The dolomite plant building is of reinforced concrete; it is 36·3 m. (119 ft.) long and 22 m. (72 ft.) wide. It is in a line with the gas producer building. The dolomite is sintered at Montchanin, whence it is brought by rail and unloaded into reinforced concrete bins. From these it is taken, crushed and stored in hoppers. The tar is poured from the tank wagons directly into two vats located in a pit 3 m. (9 ft. 10 in.) deep, 6 m. (19 ft. 8 in.) wide and 8 m. (26 ft. 3 in.) long, which rest over two grates for heating up the tar. The upper edge of the vats is 0·5 m. (1 ft. 7 in.) above the floor level. They have each a capacity of 15 cub. m. (530 cub. ft.). From the vats, the tar is delivered by a pump having a capacity of 300 litres (66 gallons) per hour into an intermediate receiver built round the chimney of the dolomite plant, at a height of 4·5 m. (14 ft. 9 in.), where it is maintained hot by the waste heat, and whence it is delivered to the mixer through a rose.

The brick stores is in a line with the gas producer building. Close to this is the general stores and maintenance shop, this latter containing a smithy, machine tools, and fitters' benches.

The electric sub-station takes three-phase current at 5,000 volts from Messrs. Schneider's Creusot establishments and transforms it to continuous current at 500 volts and 250 volts for driving the motors of the new steel works. Lighting is supplied from three sets of transformers distributed over the steel works, the current for this being three-phase at 120 volts.

The slag bottoms are dumped in a trench 120 m. (394 ft.) long and 5 m. (16 ft. 4 in.) wide, located in a line with the casting bay and served by two normal gauge lines on each side; the slag is broken up and is distributed according to its composition.

The locomotive shed can accommodate eight locomotives. The steel-works' offices are in a light building in a line with the scrap stores.

The water consumption is a maximum of 700 cub. m. (24,720 cub. ft.) per 24 hours and per furnace; the water required for the gas producers is included in this figure. Generally, the water consumption varies from 550 cub. m. to 700 cub. m. (19,424 cub. ft. to 24,720 cub. ft.).

The total weight of the iron and steel used in the structure of the steel-works, including the ingot and ingot mould depot, the stripping and ingot delivery bay, furnace platforms and flooring of the scrap stores is about 8,000 metrical tons. The weight in the case of the gas producer bay is about 1,400 metrical tons. In carrying out the earthwork 27,000 cub. m. (953,550 cub. ft.) were moved; the ordinary masonry work involved 36,000 cub. m. (1,271,400 cub. ft.) and the fireproof masonry 10,000 cub. m. (353,170 cub. ft.). Space is provided for ultimately extending the steel-works at the southern end by the construction of four more furnaces and their gas producers, and at the northern end by a shop for casting and compressing heavy ingots.

ELECTROPLATING.—A joint meeting, organised by the Faraday Society and the Sheffield section of the Institute of Metals, will be held in the Mappin Hall of the Department of Applied Science of the University of Sheffield, St. George's-square, on Friday, November 19, to discuss papers dealing with various aspects of electroplating. Communications are promised from representatives of the scientific side of the electroplating industry in London, Birmingham and Sheffield. Those desirous of taking part are invited to communicate with the Sheffield Local Honorary Secretary of the Faraday Society, Dr. F. C. Thompson, Department of Applied Science, University of Sheffield.

THE SHIPBUILDING, ENGINEERING AND ELECTRICAL EXHIBITION AT GLASGOW.

THE specialised exhibition has been held so frequently and in such large variety in London, at Olympia and the Agricultural Hall, that one has almost come to consider these its natural and spiritual homes. For certain types of show this may be the actual state of affairs, but very clearly in the engineering sphere London has no essential claim to be considered the representative centre. Much engineering work is carried on in and around London—much more, indeed, than is, we think, generally recognised—but neither the magnitude, nor importance, of this work enables London to claim a first place, nor a prescriptive right to form the scene of every engineering show. It is very evident that if it is to be on an adequate scale any engineering exhibition must be held in an important centre, and the actual towns or cities, in the British Isles, which have at the same time the sufficiently important engineering connection and the necessary magnitude to conveniently accommodate visitors is not very large.

There is no need to attempt an enumeration of our various representative engineering districts, but it is matter of no dispute that Glasgow and the area of which it is the centre, stands among the first. In view of this, and in virtue also of its distance from London, Glasgow certainly forms an admirable centre for an engineering exhibition, and one may both hope and anticipate that the display which opened on Monday last at the Kelvin Hall in that city will be very successful. The exhibition has been promoted by the Glasgow Corporation, and although we have received no official intimation of the ideas underlying this promotion by the local authorities it may be useful to consider for a moment what purposes an exhibition of this kind may be expected to serve. It is obvious, in the first place, that it should be of commercial value. Engineers and manufacturers in Scotland will have an opportunity of seeing an important collection of modern engineering appliances, and will possibly, and even probably, have brought directly to their notice machines, or tools, of value to them in their business. This applies very particularly to manufacturers who are not engineers. Such manufacturers are frequently curiously out of touch with the more recent advances in engineering work, and direct evidence of methods of superior merit to those they now use should be of benefit both to them and to the engineer who makes the appliances.

If an engineering exhibition should lead to an improvement in methods and an increase in output it might well be considered to have justified itself. There is, however, another important aspect in which such an exhibition may be regarded, and one which, in view of its official promotion, was probably kept in view in connection with the present show. This is the educational value which naturally resides in the assemblage of a representative collection of modern engineering appliances. The education of the non-engineering manufacturer we have already referred to. What we now have in mind is the education rather of the student and the workman. The value to an engineering student of such an exhibition need not be insisted on. He may not understand all he sees, but he will understand much. He will get many new ideas and will be brought more closely in touch with the practical workshop point of view, which is the point of view to which he must ultimately come himself if he is to be a successful engineer. The education of the workman is of equal importance. In spite of all we have heard of the present attitude of labour we believe that the average skilled man takes a keen technical interest in his job. The exigencies of output, and of commerce, frequently condemn him to a very small participation in modern engineering advance, and the opportunity which such an exhibition offers of bringing him a little closer into touch with what is being done, and what can be done, in his trade should not be neglected. We trust the Glasgow employers will make generous arrangements for their skilled workpeople to visit this show.

The Kelvin Hall, in which the exhibition is held, is a large single-storey structure, lending itself very

well to the purpose. The building covers some 200,000 sq. ft. of floor space, and there are 2½ miles of passages between the stands. We do not know that these figures will in general convey very much, but we wish to make it clear that the exhibition is an important one. There are in all over 300 stands, and practically all of these contain genuine engineering exhibits, there being a notable absence of the padding with which one has not infrequently found such exhibitions helped out. Those from other parts of the country who may contemplate visiting Glasgow will find the exhibition compare very favourably with similar displays which have been held elsewhere. Before proceeding to a description of the exhibits there is a minor point on which we would like to congratulate the exhibition authorities. Whether it is due to the price of paper or to the good judgment of Mr. James M. Freer, the exhibition manager, we cannot say, but we are quite prepared to give Mr. Freer the benefit of the doubt. The matter to which we refer is the size of the catalogue. This is in every way adequate, and runs to 336 pages. At the same time it is of convenient size, and may easily be carried in the side pocket. It compares more than favourably with the ridiculous tomes which one has more than once been expected to take round exhibitions at Olympia. It would be well if exhibition promoters would realise that once a catalogue becomes a labour to carry, it is likely to defeat its own objects and fail to be used at all.

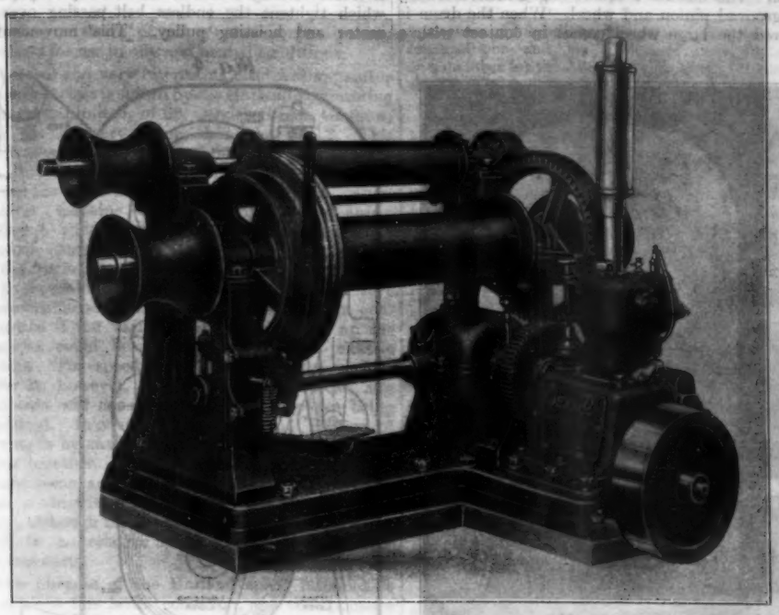


Fig. 1. Oil-Engine Driven Hoist; The Savix Marine Engine and Motor Company, London.

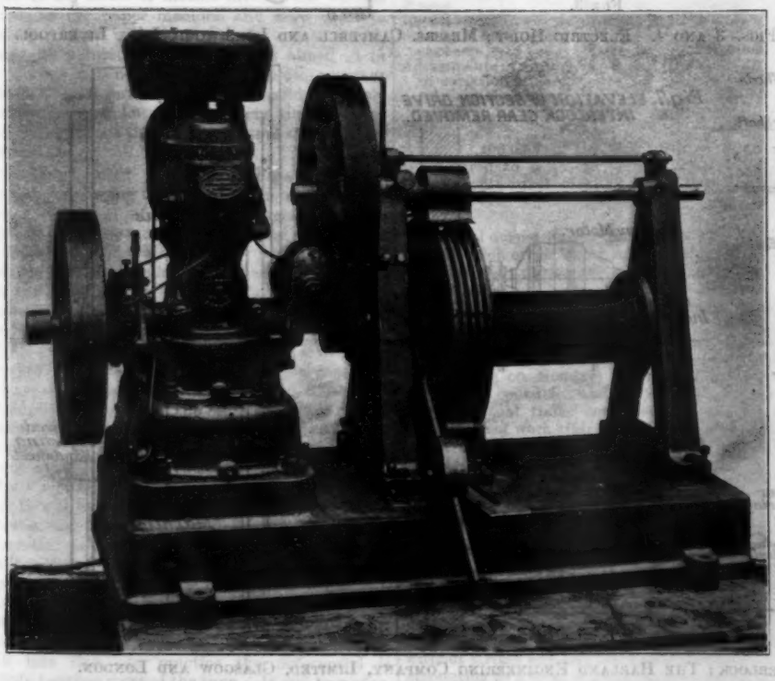


Fig. 2. Oil-Engine Driven Hoist; Messrs. E. S. Hindley and Sons, Bourton, Dorset.

The exhibition in its title claims to deal with shipbuilding, engineering and electrical matters, and it touches each field very fairly. The first of these is an art which it is always difficult to bring within the dimensions of any ordinary building, and the ship, the product of the art, has naturally to be represented by the model. In this direction an interesting display is to be seen at the Kelvin Hall as would naturally be expected in an exhibition held in one of the homes of shipbuilding. Unless, however, one is to enter into a discussion of ship forms and cognate matters it is difficult to say anything about these models except that in general they are very charming and in the beauty of their workmanship make one proud of the possibilities of human handicraft. The exhibition is not very strong in tools (a matter about which the Machine Tool Trades Association may possibly know something) so that the constructional side of shipbuilding is not heavily represented, except in the non-machine tool lines. Pneumatic hammers, riveters, &c., and electric light and acetylene welding and cutting appliances are shown by a large number of firms. The accessories of shipbuilding, lifeboats, davits, steering gears, &c., are also well represented.

In the class which may be called mechanical engineering exhibits it is no surprise to find appliances connected with the use of oil as a fuel forming a very prominent part of the total. For a large number of years the advantages and disadvantages of oil have been a subject for discussion and trial in engineering circles, but at the present time the matter in many directions has got beyond the stage of discussion, and there are probably no engineering applications which are advancing more rapidly at the present time than those connected with the utilisation of oil fuel. Examples both of the oil-firing of steam boilers and the internal-combustion engine in various forms are very adequately represented at the show. We have made no very careful statistical summary, but on a rough count at least 16 different forms of oil engine are on show. In view of difficulties imposed by questions of weight, most of these are naturally of small or moderate size, suitable for the launch or fishing boat rather than the coaster or the ocean steamer. Within its limits, however, this phase of the exhibition is of much interest, and we shall have occasion to return to it. The largest oil engine actually shown is, we think, a 300-h.p. six-cylinder Diesel exhibited by the North-British Diesel Engine Works, Ltd., of Whiteinch, Glasgow.

Other types of engineering plant are in general well represented, and without making any attempt to reproduce the catalogue we may say that pumps of many forms, superheaters, engineering and navigational instruments, furnaces, tools, steels, wire ropes, coal cutters, steam traps, feed-water regulators, road vehicles, &c., are well represented. The steam engine in its smaller sizes is also not neglected, and many examples of marine lighting sets are to be seen. This is a type of plant which has reached a degree of reliability and capability of running day in and day out without giving any trouble, that the oil engine in its many forms may well envy. We cannot leave the subject of steam engines without referring to the most excellent steam locomotive displays made by the North British Locomotive Company and Messrs. William Beardmore and Co. The North British exhibit consists of the underframe of a 3 ft. 6 in. gauge express engine fitted with the cylinders and running gear. The Walschaert valve gear is in place and arranged to be set in motion, a model of the steam ports being connected up to it to show the action of the gear. Messrs. Beardmore show one of their locomotive boilers and a very complete collection of finished wheels, axles, crankshafts, &c.

On an actual count of stands we think that electrical exhibits would head the total, but this would only be achieved by taking together, say, wireless telegraphy outfits and electric lifts. The number of groups into which the electrical stands may reasonably be divided is, however, almost as great as those which we have described as mechanical engineering exhibits, and electrical work is not over-represented. In view of the employment of electrical appliances in almost every branch of engineering, one must expect to find a fair proportion devoted to them and the display which is to be seen only fairly represents the importance of the subject. The various exhibits range from

power plant—motor generators, &c.—to telephones and telegraphic material. Electric coal cutters are fairly well represented, which is natural in view of the probably greater use of mechanical coal-cutting plant in the Scotch coalfields than elsewhere in the British Isles. This is of course largely due to the prevalence of thin seams.

In turning to a detailed account of some of the exhibits, we should say that in view of the short time which has elapsed since the opening of the exhibition it has not been possible to pretend to deal adequately this week with the whole of any particular class of apparatus. We will begin by referring to some lifting appliances, but do not suggest that there may not be others which we shall find it advisable to refer to later. Our first illustrations, Figs. 1 and 2, on the previous page, show examples of a type of appliance which has developed considerably of late years in connection with the advance of the oil engine and the increasing use of oil fuel. It is clearly a convenience in an oil-engine propelled ship, especially when of a moderate size, to have oil-engine driven winches. This avoids the need of a donkey boiler and a standard steam winch plant. A self-contained oil-engine driven winch also, however, clearly has conveniences for much land work, especially when a temporary plant is required to deal with a considerable amount of lifting. Neither of the two winches, or hoists, which we illustrate, are of very large power, but either should be a great convenience in many such cases as we suggest.

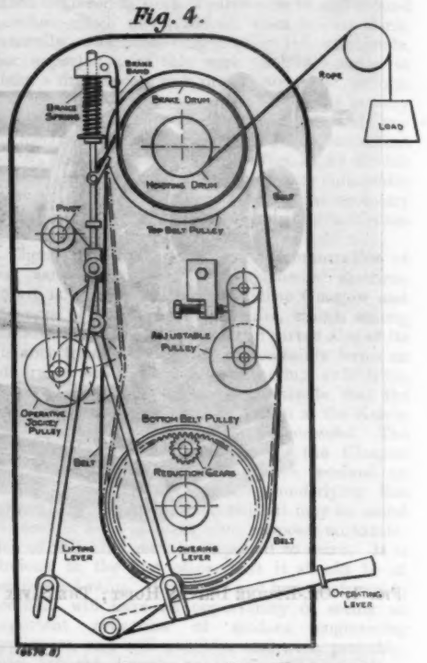
Our first illustration, Fig. 1, shows a hoist which is exhibited at Glasgow by the Safix Marine Engine and Motor Company, of 16, Bevis Marks, London, E.C. 3. As will be seen it is driven by a single cylinder vertical engine. This has a cylinder, 110 mm. by 120 mm., and is rated at 6 h.p. The engine runs on paraffin and is arranged to start on petrol. Ignition is by Bosch magneto. The engine is geared up to a cross-shaft which drives the lower shaft of the hoist through bevel wheels totally enclosed. The other end of this shaft carries a grooved pinion which can be lifted by a hand lever to engage the large grooved wheel on the hoisting drum. The same lever controls a band brake which is normally in operation. When the lever is held in its central position the drum runs free. The gear-box carrying the bevel wheels acts as a trunnion pivoted around the cross-shaft carrying the spur wheel, so that the lifting of the grooved pinion and with it the lower shaft of the hoist does not disturb the proper engagement of the bevel wheels. The hoist will lift 8 cwt. at 100 ft. per minute. Our second illustration, Fig. 2, shows an oil-engine driven hoist exhibited by Messrs. E. S. Hindley and Sons, of Bourton, Dorset. The engine is by the Hamworthy Engineering Company. In this case, as will be seen, the driving shaft of the hoist is placed above the drum and is driven direct from the engine by a pinion and spur wheel. The grooved pinion is brought into contact with the grooved wheel on the drum by lifting the drum. This is neatly arranged for by carrying the drum on a shaft carried in eccentrics on the main A frames, so that rotation of the shaft lifts, or lowers, the drum. This ensures a square engagement between the grooved pinion and wheel. When the drum is lowered the large wheel comes in contact with a wood block mounted on the bedplate, which acts as a brake. When half lifted the drum runs free.

Another lifting appliance, but of a somewhat different class, is illustrated in Figs. 3 and 4 on this page. This is an electric hoist suitable for ship and other purposes and is made in three sizes to deal with lifts of from 1¼ cwt. to 5 cwt. The appliance is a simple one, with little or nothing to get out of order and is particularly suitable to serve as an ash or baggage hoist. Appliances fitted for these services are particularly liable to rough treatment and are put in the hands of very unskilled people, so that a simple construction and one requiring no knowledge on the part of the user is particularly desirable. As will be seen from Fig. 3 the hoist is a self-contained unit with all working parts enclosed in the cast-iron case. The winding drum and the operating handle are the only moving parts outside. The method of operation will be followed without difficulty from Fig. 4. As will be seen no clutches are employed, and lifting is carried out by the movement of a jockey pulley which tightens the endless belt passing over the motor and hoisting pulley. This movement is controlled by the handle, which must be held over to keep the jockey pulley in action. When the handle is freed the belt is slack and no drive takes place. The electric motor runs continuously. Moving the handle in the other direction brings a band-brake on the hoisting shaft into operation through the link motion, which can be seen in Fig. 4. A centrifugal brake is also fitted on the winding drum shaft to control the lowering speed and prevent damage to the article being lowered when it reaches the ground.

The hoist is fitted with ball bearings and the motor gears are machine cut. As will be seen from Fig. 4, in addition to the jockey pulley, which

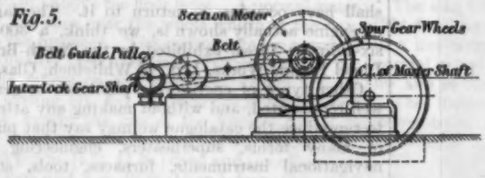
Fig. 3.

Fig. 4.



Figs. 3 and 4. Electric Hoist; Messrs. Campbell and Isherwood, Ltd., Liverpool.

Fig. 5.



DETAIL OF SECTION DRIVE

Fig. 6.

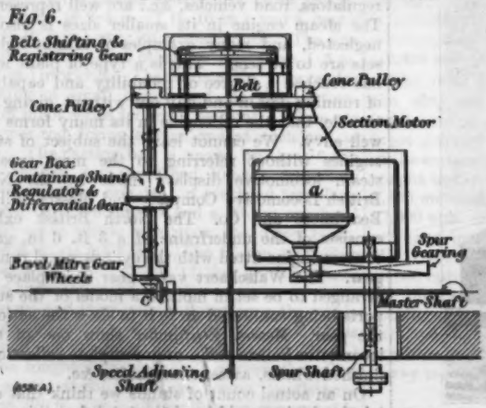


Fig. 7. ELEVATION OF SECTION DRIVE. INTERLOCK GEAR REMOVED.

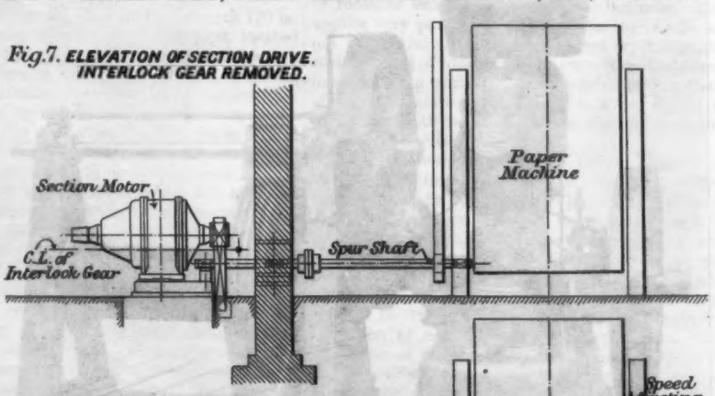
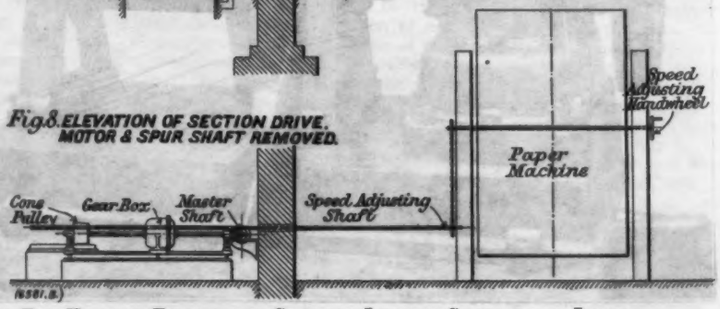


Fig. 8. ELEVATION OF SECTION DRIVE. MOTOR & SPUR SHAFT REMOVED.



Figs. 5 to 8. The Harland Speed Interlock; The Harland Engineering Company, Limited, Glasgow and London.

controls the lifting, there is a fixed but adjustable jockey. This is used for taking up permanent stretch in the belt. The hoist is constructed by Messrs. Campbell and Isherwood, Limited, of Raleigh Street, Bootle, Liverpool. In addition to this hoist Messrs. Campbell and Isherwood show steam-driven ship lighting sets, switchboards, portable electric drills and electro-magnetic drill stands. This firm also makes a speciality of gear cutting and show some interesting examples, including a series of paper pinions, particularly intended for use in oily and heated conditions.

A novel and very interesting electrical apparatus of another class is shown by the Harland Engineering Company, Limited, of 66, Carrick Street, Glasgow, and 5, Chancery Lane, London, W.C.2. This illustrates the Harland patent speed interlock for use in connection with paper-making machines driven by individual electric motors. A paper-making machine requires driving mechanism having a wide range of speed, and at the same time one such that the relation between the speeds of the various units of the machine do not vary. A paper-making machine of course covers a very considerable area, and it would clearly be a convenience if the various units which make up the machine could be driven by individual electric motors. The speed relation between the various units is, however, of great importance, as any variation will cause breakage of the paper being produced. In view of this the normal method of driving is by shafts and countershafts tying all the parts together. This is somewhat expensive and cumbersome, and we believe that some progress has been made with the individual electric driving of units, although the difficulty is to arrange that there shall be no relative speed variation between the various units.

The purpose of the Harland speed interlock is to achieve this latter condition, and the appliance is now being installed on important plants, both in this country and Canada. The arrangement is a very pretty one, and its effect is to control the speeds of the series of motors driving the various sections of the paper machine and keep them in constant relation with the speed of a waster motor. It may be pointed out that what is aimed at in this case is not necessarily an absolute constant speed (although serious variations would obviously be objectionable) but an absolutely similar speed at all times for all the driving motors of the paper machine.

The arrangement is shown in Figs. 5 to 8 on page 636. Referring to Fig. 6 *a* is one of the motors driving a section of the paper machine through open-gearing as shown. The outer end of the shaft of this motor carries a cone pulley which drives by a belt another cone pulley, set the other way round. This second pulley is mounted on a shaft lying parallel to the motor shaft and connecting to the gear-box *b*. This gear-box contains a differential and the opposite wheel of the differential is mounted on a shaft which is connected by the bevel gearing *c* to the master shaft which is carried the full length of the paper machine. The master shaft is driven continuously by a standard motor in terms of which the speeds of all the section motors are regulated. As one side of the differential is driven by section motor *a* and as the other is driven from the master shaft it will be evident that so long as the speed of motor *a* does not vary the floating wheel of the differential will make no movement. If, however, motor *a* slows down or speeds up, the differential wheel will begin to rotate, and in doing this will operate a rheostat which is contained in the differential box *b*. This rheostat cuts in, or cuts out, resistance from the field of motor *a* and so pulls it back into line. In practice the differential is slightly hunting most of the time. It will be understood that one of these differential boxes is fitted in connection with each section motor, but that the master shaft is common to all, so that all the section motors are regulated in terms of the same master motor. In conclusion, we should say that the cone pulley arrangement to be seen in Fig. 6 and already referred to, is incorporated to allow of slight adjustment between the relative speeds of the master shaft and motor shaft when first setting-up. This is carried out by moving the belt on the cone pulley by the belt shifting gear shown. When the gear has once been set the position of this belt is not again interfered with.

(To be continued.)

INDUSTRIAL NOTES.

Mr. William Brace, M.P., has been offered and has accepted the post of Labour Adviser to the Department of Mines, Board of Trade. This involves the severance of his official connection with the miners' organisations and his retirement from Parliament as a member for the Abertillery division of Monmouthshire.

In a written reply to Sir James Cory, Mr. Bridgeman, Secretary of the Department of Mines, has stated that the loss in coal output through the coal strike is estimated to be between 13,000,000 tons and 14,000,000 tons, the loss in wages to the miners being between 14,000,000*l.* and 15,000,000*l.* Among workpeople insured against unemployment under the Unemployment Insurance Act, or the Out-of-Work Donation Scheme for ex-service men, the total number of unemployed rose by approximately 270,000 between October 8 and November 4; it would appear probable, therefore, that the total increase in the number of unemployed—apart from those employed in the coal mines—cannot have been much less than 350,000, and may have been greater. In addition, a large number of workpeople were reported to have been on short time. Sir Robert Horne has stated that the Government's expenditure on publicity in connection with the coal strike amounted to approximately 11,750*l.*

Mr. Bridgeman has issued the following statistical information with respect to coal production, wages, profits, royalties, salaries, and other expenses:—

	1913 (Six Monthly Basis).	1920 (First Six Months).	Per Cent. Increase or Decrease.
Disposable coal produced	132,000,000	108,000,000	− 18
Pithead value (including proceeds of miners' coal) ...	£ 73,000,000	£ 192,700,000	+164
Wages	45,300,000	129,800,000	+185
Royalties	3,000,000	3,400,000	+ 13
Salaries and other expenses	13,000,000	37,200,000	+186
Adjustments in respect of variation of capital since the pre-war period	£nil	£2,000,000	
Profits	11,000,000	20,300,000	+ 85

About 11,400,000*l.* of the 1920 profits is estimated to be required to meet the profits (after deduction of excess profits duty) which enure to the colliery owners under the Coal Mines (Emergency) Act, 1920.

The coal output during the week ending October 23, the first week of the strike, was 12,500 tons, as against 4,611,600 tons during the preceding week.

Mr. Neal (Parliamentary Secretary, Transport Ministry) stated last week, in the House of Commons, that the Minister of Transport had requested the railway companies to increase their train services, commencing on Monday, the 8th inst., the earliest date found possible, and to undertake services to meet the coal traffic consequent upon the general resumption of work after the strike. Special attention would be given to the conveyance of urgent consignments. Each company would, as usual, make its own announcements as to the resumption of services. The Ministry of Shipping were making arrangements in the same way for steamers.

The Sheffield District Council of the National Amalgamated Union of Labour held its quarterly meeting last Saturday, when Councillor A. J. Bailey stated that there had been during the quarter 18 important wages disputes, which directly affected 11,612 members; all these disputes had been settled without strikes and had resulted in increases in wages amounting to a total of 212,443*l.* per annum.

Mr. W. A. Stevenson, president of the Associated Society of Locomotive Engineers and Firemen, retires from that office at the end of the present year, and ceases his connection with the Executive Committee, on having been elected to the Urban District Council of Crayford, Kent. He remains a member of the society.

We referred on page 537 *ante* to a deadlock which had occurred in the commercial road transport industry. The strike which had broken out in the West Riding of Yorkshire came to a close last Friday, the men having agreed to the following terms: Single-horse carters to have an increase of 7*s.* per week; two-horse carters an advance of 6*s.* per week; drivers of Ford wagons and light motors an advance of 5*s.* per week; drivers of heavy petrol and steam wagons an advance of 4*s.* per week; drivers' mates an advance of 3*s.* per week. The men had struck on the demand for a 22*s.* advance, with a minimum of 4*l.* 7*s.* per week. Later news, received at the time we are going to press, would seem to point to dissatisfaction still existing in some Yorkshire centres.

Speaking in London last week, when he was the guest of the United Wards' Club of the City of London, Mr. Winston Churchill briefly reviewed the present situation in this country, and said that all strikes and threats of strikes and the loss and suffering caused by them, all talk of revolution and direct action had deeply offended the mass of the British people. There was a growing feeling that a considerable section of organised labour was trying to tyrannise the public and bully them into submission, not by argument, which everyone in a free country had the right to use, not by recognised political measures, but by brute force. There was a feeling, and he thought not unfounded, that they were hampering the scientific progress and the industry of the country, and by this they were keeping up the cost of living and so reducing the value of the wages of the working class. Trade unionists would have to review their position very carefully in the next few years if they were to preserve the great, and on the whole beneficient, influence they had exercised for so long in British public and industrial life. They had done a great work, and they had still a great work to do, for the commonwealth. The bulk of their members and most of their leaders were sincerely devoted to the broad general interests of the country, but there was an active and very voluble minority which was always trying to grab control of the organisation, and that minority, to speak frankly, had a perfectly definite and avowed intention to try to wreck the whole existing system of society, and to wreck it by any means, however violent, that might be within their reach. Responsible leaders of the trade unions had a very great difficulty in standing up to those hotheads, and had to make continued concessions and pay constant lip-service to their extreme doctrines and formulæ.

The National Alliance of Employers and Employed, in view of the prevailing state of unemployment and the responsibilities of an increase of unemployment in the near future, have decided to urge upon the Government: (1) To pass immediate legislation to enable unemployment benefit to be paid as from November 8 under the Unemployment Insurance Act, 1920, irrespective of the contributions payable under Section 5 of the Act and to make the restrictions of 8 and 15 weeks respectively inapplicable until December 31, 1920, extending this privilege from time to time during the industrial emergency. (2) To make special arrangements for the supply of available unemployed labour to schemes or contracts, whether under the control of the Government, municipalities or private persons, which are of a sound economic nature, where such schemes or contracts are held up for want of labour and that union rates of wages be guaranteed in all such cases. (3) To call upon each industry to measure its own unemployment compared with its nearest normal period and to urge upon employers and trade unions concerned, that they must come together and arrange schemes for the division of available work. (4) To arrange that any balance of labour still unabsorbed be referred to district councils, which shall consist of employers and trade unionists, and which the National Alliance are prepared to provide, to arrange for temporary measures of employment in conjunction with municipalities and district authorities.

These resolutions were sent to the Prime Minister and to the Minister of Labour on the 8th inst., asking that a deputation be received by them at an early date to give further explanations.

A meeting of representatives of the Federation of Master Printers and of Newspaper Proprietors' interests met last week representatives of the Typographical Association, in the course of which a settlement of the wages question was arrived at. Following the meeting, Mr. A. E. Goodwin, secretary of the Federation of Master Printers, stated that "the employers agreed to recommend their constituents to grant an increase of 5*s.* per week to all adult members of the Typographical Association in all grades of towns, this increase to come into force on the first pay day following Monday, November 15, after ratification by both sides. The Typographical Association will submit this offer to a ballot of their members as early as possible."

The Typographical Association Executive, it is

THE "BOREAS" BRIQUETTING PRESS FOR CAST-IRON TURNINGS.

CONSTRUCTED BY THE DANISH MACHINE COMPANY, ENGINEERS, COPENHAGEN.

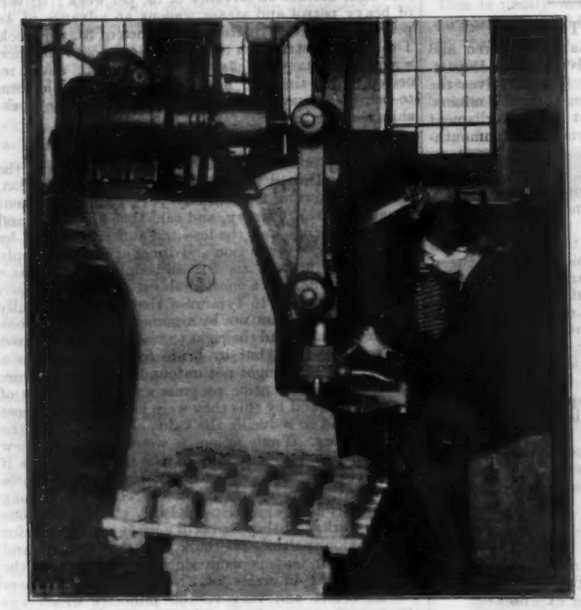
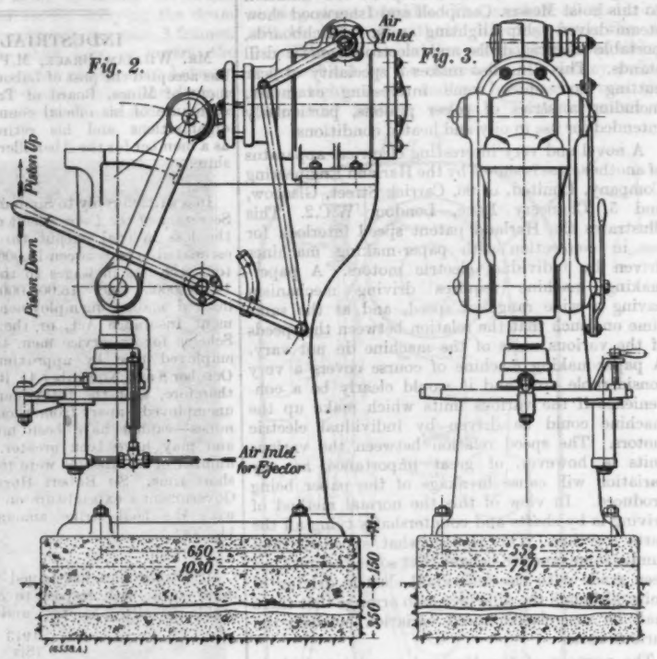


FIG. 1.



reported, have agreed to recommend the acceptance of these terms.

Speaking in Parliament last Tuesday, Dr. Macnamara, Minister of Labour, said that a number of schemes for afforestation, the improvement of harbours, and building of light railways, were in process of being carried out. The Forestry Commissioners propose planting 5,000 acres during the present winter, and this was expected to employ about 500 men. In addition to a number of schemes for harbour development and maintenance under consideration, a number of harbour schemes financed from the Development Fund were at present in progress in Scotland and Ireland. In connection with light railways, the Ministry of Transport had established a Development Committee, which was considering various schemes which had been put forward with a view to selecting those most urgently required in the national interests. With regard to the whole matter, the Cabinet Committee on unemployment was considering further avenues which seemed to offer an opportunity of providing employment.

A meeting of the Cleveland ironstone mineowners was held recently in Middlesbrough; representatives of the miners attended, and the meeting was presided over by Sir Hugh Bell. The main question dealt with had reference to the application of the recent coal settlement to the Cleveland ironstone miners and the Weardale limestone quarrymen. The chairman intimated that the associated owners were prepared to pay the advance for the current quarter, at the same time pointing out that some of the details of the coal settlement were obviously inapplicable to the ironstone and limestone industry. The owners hoped that between now and the end of the year some arrangement might be effected by which it would be possible for the Cleveland men to settle their wages arrangements with the owners direct.

The British imports in September, 1920, were valued at 152,700,000*l.*, and the total exports at 130,800,000*l.* The corresponding figures for October were, imports 149,900,000*l.*, and total exports 128,400,000*l.* The figures for October were adversely affected by the coal strike.

ELECTRIC CABLES AND MACHINERY STANDARDS IN BELGIUM.—Copies (in French) of the official standards for electric cables and machinery, adopted by the Chambre Syndicale des Electriciens Belges, may be consulted by British firms interested at the Inquiry Room of the Department of Overseas Trade, 35, Old Queen-street, Westminster, S.W. 1. A knowledge of these standards is essential to British electrical engineering firms desiring to develop their business in Belgium. The general conditions of Government contracts are also given.

THE "BOREAS" BRIQUETTING PRESS FOR CAST-IRON TURNINGS.

A CONVENIENT means of usefully disposing of cast-iron turnings, borings and filings has been introduced in the form of a simple press by which such refuse material can be formed into briquettes and used in the cupola. Up to 15 per cent. of briquettes can, we understand, be used with advantage for the production of ordinary machine castings, and for special castings, such as engine cylinders, the proportion of briquettes can be further increased. The resulting iron is claimed to be compact and tough, and to produce stronger castings than would be made from pig and scrap alone, while the briquettes have the additional advantage of providing a convenient means for introducing silicon or manganese into the metal. The plant is suitable for use in engineering works having their own machine shops and foundries, the briquettes being either used in the latter or sold. It can also be advantageously employed by foundries which are in a position to purchase cast-iron turnings from a number of small machine shops.

The press, which is the invention of a Danish engineer, Mr. A. Houmoller, B.Sc., is known as the "Boreas," and is made in Copenhagen by the Danish Machine Company, but the sole rights for this country have been acquired by the Colley Engineering and Machinery Company, Clun House, Surrey Street, Strand, London, W.C.2. The photograph and line drawings reproduced above in Figs. 1 to 3, show the appearance and general arrangement of the press, which, it will be seen, is of the knee type with a vertical ram operated by a horizontal pneumatic cylinder through the medium of simple toggle mechanism. The table of the press is provided with a mould attached to a pivoted arm, and the mould is filled with a mixture composed of turnings, with 5 per cent. of slaked lime and 5 per cent. of water. When filled on the side of the table, the mould is swung round under the ram for pressing and afterwards returned to its original position where a small auxiliary pneumatic cylinder is provided for the purpose of ejecting the finished briquette. The air pressure used is from 90 lb. to 100 lb. per square inch, and the method of controlling its admission to the main cylinder and to the ejector is clearly shown in Figs. 2 and 3.

The finished briquettes, a number of which are visible in Fig. 1, are in the form of truncated cones and each weighs about 6½ lb. After pressing, the briquettes are placed on drying trays, where they are allowed to remain for some days until they are sufficiently hard to be handled, when they are piled in the open air for tempering. The latter process takes from two to four weeks, according to the state of the weather, and on its completion the briquettes are sufficiently hard for transport to, and use in, the cupola, though they must be handled with care. When placed in the furnace they should first be covered with a layer of coke in order to prevent them from being crushed by the pig iron or large pieces of scrap. The melting of the briquettes takes place from the outside, and a thin skin, which forms over the surface, prevents the absorption of sulphur and other impurities. The percentages of manganese, phosphorus and sulphur are not altered during melting, but those of carbon and silicon are reduced rather rapidly. The variation of carbon within small limits, however, has no effect on ordinary mixtures of iron, and it need not be considered unless the proportion of briquettes in the charge exceeds 10 per cent. On the other hand, it is desirable to add a certain quantity of silicon to the turnings used for making the briquettes.

With the press illustrated an unskilled operator can produce from 120 to 150 briquettes per hour, and the press can deal with about 100 tons of turnings per annum, which would be the normal production of works with a machine shop, employing about 200 men. The cost for briquetting alone with power at 2½*d.* per kilowatt hour and labour at 2*s.* per hour, including a suitable allowance for overhead charges and depreciation, is given as 1½*d.* per briquette, and as the value of the turnings would be about the same amount, the total cost per briquette is about 3*d.* The wastage in melting amounts to some 20 per cent., so that each briquette produces over 5 lb. of iron. The actual working costs, of course, vary somewhat in accordance with the conditions under which each installation is operated, but the figures given above are typical and can easily be modified for any particular case.

A somewhat similar press, but operated by belt power and intended for use where compressed air is not available, is also made. In this machine the toggle levers are operated by a horizontal screw shaft fitted with fast and loose pulleys and driven by open and crossed belts. The direction of rotation of the shaft, and the consequent vertical movement of the ram, can thus be reversed at will by shifting the belts.

THE INSTITUTION OF CIVIL ENGINEERS: AWARDS FOR PAPERS.—In addition to awards already announced for papers read at meetings, the Council of the Institution of Civil Engineers have made the following awards for papers published without discussion in the "Proceedings" of session 1917–18, the issue of which has been delayed by conditions due to the war: A Telford gold medal to Mr. P. L. Pratley, M.Eng. (Montreal); a Crampton prize to Mr. G. M. Clark, M.A. (Johannesburg); Telford premiums to Mr. J. L. Calvard (Hull) and Mr. S. S. D. Robertson, B.Sc. (Hawthorn, Australia). A paper by Mr. G. H. Duggan (Montreal) was also found to merit the award of a Telford gold medal, but the author, being a member of the Council of the Institution, is by rule ineligible to receive a medal.

THE "TURBINE" FORCED-DRAUGHT FURNACE.

CONSTRUCTED BY THE TURBINE FURNACE COMPANY, LIMITED, ENGINEERS, LONDON.

Fig. 1.

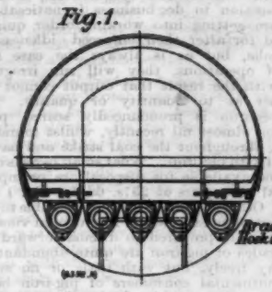


Fig. 2.

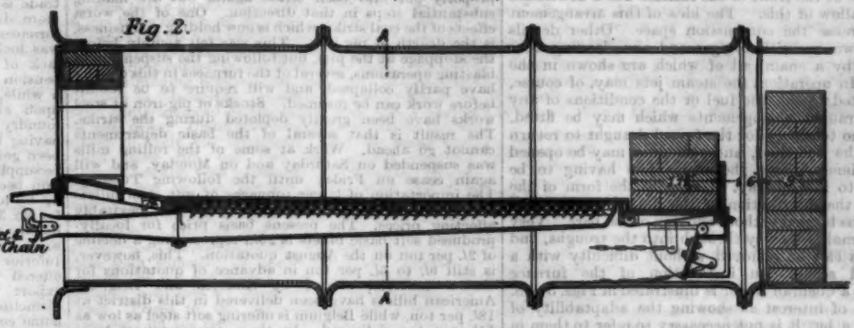


Fig. 3.

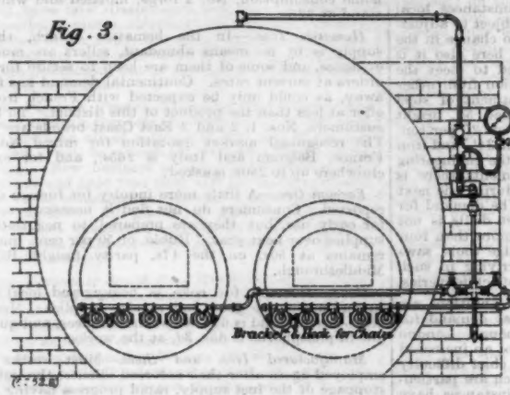


Fig. 4. SECTION ON A.A.

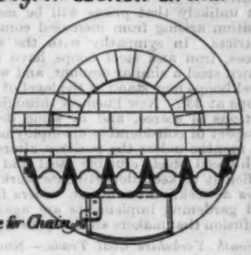


Fig. 5.

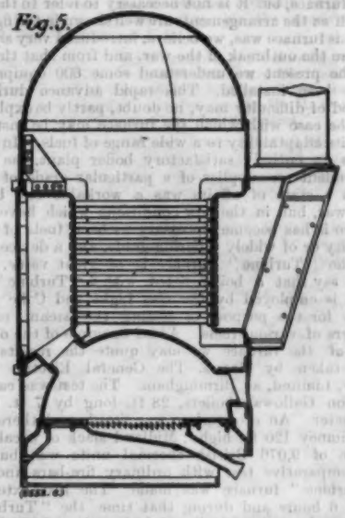


Fig. 6. SECTIONAL ELEVATION

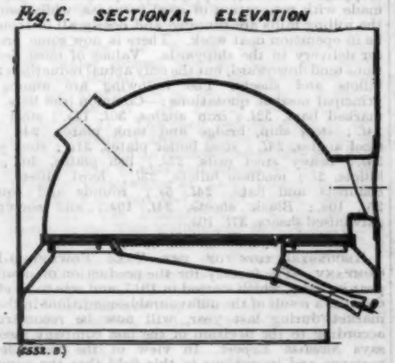


Fig. 7. HALF FRONT ELEVN HALF CENTRE SECN

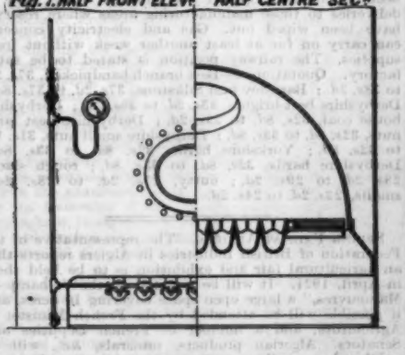
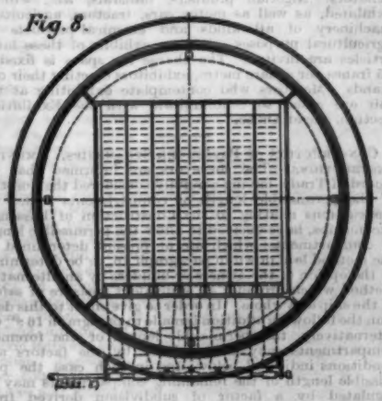


Fig. 8.



THE present fuel situation and the fact that there are no indications of any important fall in the cost of fuel in the future, render any appliances for utilising the cheaper, or poorer, grades of great importance. Much has, of course, been done in various directions to accomplish this, but in many cases expensive reconstruction work is necessary before the appliances can be utilised, so that the ease with which it can be installed would appear to be not the least valuable of the features of the furnace which has been brought out by Messrs. The Turbine Furnace Company, Limited, of 5, Budge-row, London, E.C. 4. The appliance has other important qualifications, however, as will appear in the course of this description. For the moment it may briefly be said that it will efficiently burn almost anything which can be described as fuel; coke breeze, slurry, small slack, cinders and similar poor fuels are being successfully utilised in many boilers to which the furnace has been fitted.

The details of the furnace will be clearly followed from Figs. 1 to 4, above, which show an installation applied to a Lancashire boiler. The arrangement consists of a series of troughs which lie side by side, and form the base of the furnace. These troughs carry the fire-bars. As will be seen from Fig. 2, the troughs have a cross-sectional area diminishing from the front to the back. The way they nest side by side is best shown in Fig. 4. The front of each trough forms an air injector and is fitted with a steam jet. This arrangement of troughs forms one of the special features of the furnace, and it will be clear that it results in the air supply being divided up and distributed evenly over the fire. This even distribution prevents the formation of holes and uneven burning. A further special feature of the furnace lies in the form of the fire-bars. As will be seen, these are of vee section inclined to meet the incoming air blast. It is this feature of the furnace which has given it its name of the "Turbine" furnace. The air troughs can be likened to the nozzle and the fire-bars to the blades of an impulse turbine, and it will be evident that some approach to a stream-line flow of the air from the injector up through the fire will be obtained. The arrangement should certainly cut down resistance and economise the expenditure of energy in the steam jets, and the performance of the furnace in numerous installations would appear to show the arrangement to be a very satisfactory and efficient one.

The fact that the division of the incoming air through the series of troughs breaks it up and ensures a uniform supply to all parts of the fire has already been referred to. The uniform distribution which is obtained, however, also owes much to the gradually diminishing section of the troughs and the shape of the fire-bars. The overall result of the arrangement would appear to be a uniform air pressure below and throughout the whole of the furnace. The uniformity can be well seen if a thin fire is maintained, when an even burning with an absence of holes is obtained. These special air-flow arrangements naturally tend to keep down the power required from the steam jets, and as a result a small jet only is necessary. The nozzles are of gun-metal with holes something less than $\frac{1}{16}$ in. diameter. The holes are formed with a square shoulder near the entrant end with the result that considerable contraction is obtained, and a jet of considerably smaller diameter than the hole issues from the nozzle. To further economise the consumption in the jets the steam is superheated before being carried to them. This decreases the density and so decreases the quantity of steam used.

It is not necessary to say anything in great detail about the mechanical construction of the furnace, as its features are well shown in the illustrations. It may be stated, however, that the whole arrangement is self-contained and sits in the boiler flue without any drilling for bolts, or rivets, being necessary. As will be seen, front and back castings are provided on which the air troughs hang. The troughs are of uniform width, and in the cases of flues of greater, or less, diameter, more, or fewer, troughs are fitted. The fire-bars are comparatively small castings, and each holds the one immediately behind it in place. A special locking bar is used at the front end. The superheater is a simple U-tube arrangement fixed in the flue to one side of the boiler. Its position together with the run of the steam connections to the jets are clearly shown in Fig. 3. In many Lancashire boilers no great degree of superheat will be obtained with this arrangement, but the steam will

be dried and its density lowered, which is the object aimed at.

A further point which should be mentioned is that the grate is set somewhat lower than is usual. The dead plate at the front of the furnace has a downward slope to allow of this. The idea of this arrangement is to increase the combustion space. Other details are the two firebrick bridges and the cleaning door operated by a chain, all of which are shown in the figures. In operation, the steam jets may, of course, be regulated to suit the fuel or the conditions of any natural draught arrangements which may be fitted. There is no tendency for the forced draught to return through the flue door, and this door may be opened at any time without the steam jets having to be attended to in any way. Owing to the form of the bars and the distribution of the draught very small fuel may be burned without choking of the bars. Very little ash makes its way through into the troughs, and what does can be removed without difficulty with a half-round scoop. An installation of the furnace applied to a Cochran boiler is illustrated in Figs. 5 to 8. These are of interest as showing the adaptability of the furnace, but it is not necessary to refer to them in detail as the arrangements are well shown in the figures.

This furnace was, we believe, introduced very shortly before the outbreak of the war, and from that time up to the present we understand some 600 equipments have been installed. This rapid advance during a period of difficulty may, no doubt, partly be explained by the ease with which the furnace may be installed and its adaptability to a wide range of fuels. In some cases an entirely satisfactory boiler plant has been dependent on supplies of a particular grade of coal. Such a state of affairs was a workable one before the war, but in the new conditions which have now arisen it has become necessary to burn fuels of poor quality or of widely differing grade, and a device such as the "Turbine" furnace is of great value. We may say that a boiler fitted with a "Turbine" furnace is employed by the Gas Light and Coke Company for the purpose of testing the steam-raising powers of various fuels. As an example of the operation of the furnace we may quote the results of a test taken by Messrs. The General Electric Company, Limited, at Birmingham. The test was carried out on Galloway boilers, 28 ft. long by 7 ft. 6 in. diameter. An economiser was fitted, and there was a chimney 120 ft. high. Midland slack of a calorific value of 9,076 British thermal units was burned. A comparative test with ordinary fire-bars and the "Turbine" furnace was made. The test extended over 6 hours and during that time the "Turbine" furnace burned 9,034 lb. of fuel against 6,272 lb. in the ordinary furnace. It evaporated 50,800 lb. of water against 25,800 lb., giving a result of 4·34 lb. of water from and at 212 deg. F. for the ordinary furnace and 6 for the "Turbine" furnace.

Details of a test taken by Messrs. Birmingham Metal and Munitions, Limited, are given below:—

Lancashire Type Boiler, 23 ft. by 7 ft. 6 in.		Fuel Analysis. Coal.	Coke.
Economiser not fitted.	British Th. units	10,168	10,894
		per cent.	per cent.
Fuel used (various).	Volatile matter	30·84	1·95
Coal—Midland slack.	Ash	5·62	23·60
Coke—Dust from furnace coke.	Moisture ..	15·7	0·98

Type of furnace	Ordinary 3	Turbine 4	Turbine 4	Turbine 4
Duration of test (hours) ..				
Fuel—				
Class of	Coal	Coal	3 Coal 2 Coke	1 Coal 1 Coke
Total consumed lb.	2,100	3,020	4,088	3,752
Average per hour ,,	700	980	1,022	938
Average per square foot per hour	21·8	35·7	37·3	34·1
Clinker percentage ..	(Not taken)	15·1	15·0	13·6
Water—				
Total (by meter) lb.	9,433	20,400	18,900	17,000
Average per hour ,,	3,144	5,100	4,725	4,250
Average from and at 212 deg.	3,709	6,070	5,600	5,050
Comparative evaporation	100	161	151	136
Feed—				
Constant Fah.	63	65	65	65
Pressure—				
Average, pounds per square inch	53	58	52	57
Results—				
Pounds water per pound fuel, as fired ..	4·6	5·21	4·62	4·53
Pounds water per pound from and at 212 deg.	5·35	6·29	5·58	5·37
Boiler efficiency	50 p.c.	54 p.c.	50 p.c.	50 p.c.
Cost to evaporate 1,000 gallons as fired ..	s. d. 19 6	s. d. 17 2	s. d. 12 7½	s. d. 11 0
Cost to evaporate 1,000 from and at 212 deg.	16 8½	14 5	10 9½	9 4
Comparative cost ..	100	86	65	56

THE INSTITUTION OF ELECTRICAL ENGINEERS BUILDINGS.—The Council of the Institution have been informed that its premises will be vacated by the Government before the end of December, and that immediately after the Office of Works will commence the work of repairs, cleaning, &c., of the building with a view to the Institution having vacant possession of their premises early in the New Year.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Following the coal strike settlement, the Sheffield steel and engineering industries have not properly got into their stride again, but are making substantial steps in that direction. One of the worst effects of the coal strike, which is now holding up business, is the dearth of pig-iron. This was felt acutely before the stoppage at the pits, but following the suspension of blasting operations, several of the furnaces in this district have partly collapsed, and will require to be rebuilt before work can be resumed. Stocks of pig-iron at steel works have been greatly depleted during the strike. The result is that several of the basic departments cannot go ahead. Work at some of the rolling mills was suspended on Saturday and on Monday, and will again cease on Friday until the following Tuesday. The importation of larger tonnages of soft steel billets into this district from foreign countries is inevitably affecting prices. The present basis price for locally-produced soft basic billets is 23*l.*, representing a decline of 2*l.* per ton on the August quotation. This, however, is still 9*l.* to 5*l.* per ton in advance of quotations for similar material offered by America and Belgium. American billets have been delivered in this district at 18*l.* per ton, while Belgium is offering soft steel as low as 14*l.* per ton delivered. In these circumstances local quotations are purely nominal and are subject to adjustment to meet special orders. There is no change in the position of the acid steel trade, though here also it is not unlikely that prices will be modified to meet the position arising from increased competition from other districts. In sympathy with the adjustment of steel prices, iron and steel hoops have declined 5*l.*, bright drawn steel a similar amount, and wire rods 2*l.* per ton. Steel hoops now stand at the level of about 34*l.*, and iron hoops at 33*l.* New business throughout the engineering sections is scarce, and in some departments there is prospect of considerable unemployment during the next six months unless the position alters. The demand for high-speed steel, crucible steel and twist drills is not sufficient to keep departments working more than four days a week. In contrast, orders for edge tools, saws and gardening implements are again arriving in such profusion that makers are compelled to restrict deliveries.

South Yorkshire Coal Trade.—Normal conditions are slowly being resumed. There is no great demand for household fuel from this district, though London merchants are insisting on the despatch of an increased tonnage for southern consumption. The chief difficulty is in regard to manufacturing fuels, which are particularly scarce now that stocks in many instances have been exhausted. Special attention is being paid to deliveries to those manufacturing areas where reserves have been wiped out. Gas and electricity concerns can carry on for at least another week without fresh supplies. The railway position is stated to be satisfactory. Quotations:—Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

SPRING FAIR AT ALGIERS.—The representative of the Federation of British Industries in Algiers reports that an agricultural fair and exhibition is to be held there in April, 1921. It will be situated on the "Champ de Manœuvres," a large open space covering 10 acres, and if possible will be attended by the French Minister of Agriculture, and a number of French Deputies and Senators. Algerian products, minerals, &c., will be exhibited, as well as motor cars, tractors, agricultural machinery of all kinds and chemical products for agricultural purposes. Foreign exhibits of these latter articles are invited. The charge for space is fixed at 15 francs per square metre, exhibitors erecting their own stands. Members who contemplate exhibiting at this fair are asked to communicate with the Exhibitions Section, Head Office.

CONSTRUCTION OF PASSENGER STEAMSHIPS. AMENDED INSTRUCTIONS.—The surveyors are informed that the Board of Trade, having carefully considered the question of the permissible length of compartments under the Instructions relating to the Construction of Passenger Steamships, have decided to allow the permissible length of compartments, which are at present determined by the method laid down in paragraph 16, to be determined at the option of the owners or builders by an alternative method which provides an equivalent measure of safety of the ship as a whole. In order to give effect to this decision the following addition is made to paragraph 16:—"Or, alternatively, the permissible length of the foremost compartments may be regulated by the factors and conditions indicated below, and in such case the permissible length of the remaining compartments may be regulated by a factor of subdivision derived from curve B_2." (A table in the leaflet which has been issued gives certain points in this curve.) "The combined length of fore peak and the compartment immediately abaft it to be not less than 12½ per cent. of the length of the ship, and in ships 440 ft. to 570 ft. in length, the combined length of the fore peak and the two compartments immediately abaft it to be not less than 20 per cent. of the length of the ship." The following addition is made to paragraph 21: "This requirement does not apply when the permissible lengths of the compartments forward are regulated by the alternative conditions specified in the latter part of paragraph 16."

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The Cleveland pig-iron trade is still characterised by quietness, though rather more disposition to do business is noticeable. Blast furnaces are getting into working order quicker than was looked for after their enforced idleness through lack of coke, but as is always the case after suspension of operations, they will run irregularly for a while, with the result that output cannot be relied upon either as to quantity or quality. Cleveland foundry pig-iron is pronouncedly scarce, production having been almost nil recently, whilst foundries have been going throughout the coal strike and have had to be supplied with pig-iron. What small parcels of foundry iron become available for disposal are promptly taken up by local consumers at 237*s.* 6*d.* for No. 1 and 225*s.* for No. 3. Other customers find it impossible to purchase, but the position is expected to improve, in view of which some makers are prepared to discuss forward business. Inferior grades of pig-iron are quite abundant, and are offered very freely, but with little or no success for export, Continental consumers of pig-iron being very disinclined to take anything below No. 3 quality. For home consumption, No. 4 forge, mottled and white all stand at 225*s.*

Hematite Iron.—In the hematite branch, though supply is by no means abundant, sellers are much in evidence, and some of them are keen to secure forward orders at current rates. Continental demand has fallen away, as could only be expected with French iron on offer at less than the product of this district. To home customers, Nos. 1, 2 and 3 East Coast brands are 260*s.* The recognised market quotation for mixed Nos. to France, Belgium and Italy is 265*s.*, and for export elsewhere up to 280*s.* is asked.

Foreign Ores.—A little more inquiry for foreign ore is reported. Consumers do not find it necessary to buy for early use, but they are prepared to negotiate for supplies over next year. Rubio, of 50 per cent. quality, remains at 50*s.* on the 17*s.* parity freight Bilbao-Middlesbrough.

Coke.—Demand for coke is heavy, and local consumers anticipate good and regular supplies. Medium blast-furnace kind is 62*s.* 9*d.* at the furnaces, and quality low in phosphorus is 65*s.* 3*d.* at the works.

Manufactured Iron and Steel.—Most works are employed again after their enforced idleness through the stoppage of the fuel supply, rapid progress having been made with restoration of steel furnaces, whilst some of the rolling mills are running, and nearly all of them will be in operation next week. There is now some pressure for delivery to the shipyards. Values of most descriptions tend downward, but the only actual reductions are in billets and sheets. The following are among the principal market quotations:—Common iron bars, 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; steel bars, 24*l.*; steel ship, bridge and tank plates, 24*l.* 10*s.*; steel angles, 24*l.*; steel boiler plates, 31*l.*; steel joists, 24*l.*; heavy steel rails, 25*l.*; fish plates, 30*l.*; soft billets, 2*l.*; medium billets, 23*l.*; hard billets, 24*l.*; channels and flats, 24*l.* 5*s.*; rounds and squares, 26*l.* 10*s.*; Black sheets, 34*l.* 10*s.*; and corrugated galvanised sheets, 37*l.* 10*s.*

RECONSTRUCTION OF THE VAKÖ POWDERED-PEAT COMPANY.—The factory for the production of powdered peat in Vakö, which started in 1917, and was to be closed down as a result of the unfavourable conditions in the fuel market during last year, will now be reconstructed according to the decision of the last company meeting, says *Swedish Export*. In view of the valuable experience and inventions in this field that the company represent, the decision to continue operations is received with great satisfaction.

THE MANUFACTURE OF STEEL.—In his presidential address before the Association of Ghent Engineers (Proceedings, 1920, Part 2), Mr. F. Camerman deals with open-hearth steel and basic converter steel. He states that the most experienced specialists are unable to distinguish the one from the other. After reviewing the two classes of steel he expresses the opinion that such a state has been reached both in metallurgy and testing methods that all limitations should be abolished with reference to the process to be used in the smelting of steel. Mr. Camerman is chief chemist and director of tests with the Belgian State Railways; he is, therefore, a user of steel products, and his opinion in the vexed question of binding down manufacturers to one stated process of steel smelting for a given product should carry great weight.

PERSONAL.—The Central Commercial Department of Sir W. G. Armstrong, Whitworth and Co., Limited, has removed from 3, Woodstock-street, Oxford-street, W. 1, to 10, Great George-street, Westminster, S.W. 1, the London Head Office of the firm.—The Scottish depot of Messrs. Vickers, Limited, have now removed from the temporary premises they were occupying at 75, St. George's-place, Glasgow, to their permanent address, viz., Vickers House, 247, West George-street, Glasgow, where all communications from Scottish customers should be forwarded. The telephone number is Central 2350 (3 lines), a private branch exchange to every department having been installed; the registered telegraphic address is "Vichouse, Glasgow."—Messrs. Davey, Paxman and Co., Limited, have removed their London office to Central House, Kingsway, W.C. 2. Their telegraphic address is "Paxman, Phone, London," and their telephone number 6850 Gerrard.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—The state of trade throughout the country has been gradually getting lower during the past few weeks, due largely to the disastrous coal strike. Now that the trouble is surmounted a great effort will be necessary to pull business up again, as all industries have suffered considerably. Foreign trade, which was gradually opening out got a nasty set-back, and several weeks must elapse before normal is reached. Export inquiries are not numerous.

Scotch Iron and Steel Trades.—A start is being made this week in the different Scotch iron and steel works, but as supplies of fuel are not very plentiful yet plant is being restarted slowly. By the end of the week or the beginning of next it is expected that operations will again be in full swing. Arrears of business are now considerable, and steady employment is assured to workers for the remainder of the year, as order books are well filled. The unfortunate thing about the stoppage of the steel and iron works lately was that it was compulsory and was caused by a dispute in another trade altogether. Hematite iron is scarce and may continue thus for a bit, with the result that steelmakers are likely to be kept short for the present. Shipbuilders have managed in most instances to keep going during the strike, and any little accumulations of iron and steel material have now disappeared and they are pressing for deliveries of plates, structural sections, &c. General inquiry has fallen away, but competition from abroad, chiefly Belgium and Germany, is steadily increasing. Prices are unchanged, but in view of the latter an easier tendency is noticeable.

Scotch Pig-Iron Trade.—Now that the miners have gone back to work, furnaces are being blown in and there is once again an air of activity in the various pig-iron works, but it will be a week or two before things return to normal. New business is slow, as consumers want lower prices and hold that they will get these very soon because of the contemplated arrivals of both French and Belgian pig-iron. All grades of iron are practically off the market meantime, and the sooner the smelters are in full blast again the better it will be for the general trade of the country.

Wages Advance to Scotch Steel Workers.—Messrs. Kerr, McLeod and MacFarlane, accountants, have intimated to Messrs. J. C. Bishop and Owen Coyle, joint secretaries of the Scottish Pig-Iron Board, that the average price realised for deliveries of Scottish foundry pig-iron for the quarter ending September 30, was 13*l.* 9*s.* 10*d.* per ton, and that wages will be advanced as from the commencement of the pay period nearest the beginning of November 1 by 20 per cent. on basis rates.

THE INSTITUTION OF WATER ENGINEERS.—The twenty-fifth winter general meeting (being the tenth statutory annual general meeting of the Institution) will be held at the apartments of the Geological Society, Burlington House, W., on Friday and Saturday, December 10 and 11. The chair will be taken by the President, Mr. Frederic J. Dixon, M.Inst.C.E., F.G.S., on Friday at 2.15 p.m., and on Saturday at 10.30 a.m. The following papers will be read and discussed:—(1) "The Construction of Waterworks on Land subject to Subsidence," by Mr. F. C. Cook and Mr. R. C. Moon, Assoc.M.M.Inst.C.E. (2) "The Possibilities of an Additional Water Supply to the West Midlands by Gravitation from Wales," by Mr. E. W. Dixon, M.Inst.C.E., of Leeds. (3) "The Selection of Sources of Water Supply with suggestions as to Economy in the Design and Operation of Works," by Mr. George Mitchell, M.I.Mech.E., of Aberdeen. (4) "The Madras City Waterworks" (Part II), by Mr. J. W. Madeley, M.A., M.Inst.C.E., of Madras. The offices of the Institution are 5, Victoria-street, Westminster, S.W.1.

INSTITUTE OF TRANSPORT.—The First Congress of the Institute will be held at Manchester on Thursday and Friday, January 27 and 28, 1921. On the opening day, the proceedings, in addition to official functions, will comprise two sessions, at which papers will be read and discussed as follow:—Morning Session. "The Development of Mechanical Road Transport," by Mr. C. le M. Gosselin, managing director, Messrs. H. Viney and Co., Limited, Preston. "Behind the Scenes in a Railway Locomotive Workshop," by Mr. J. W. Smith, Locomotive works manager, Great Central Railway, Gorton. Afternoon session: "Roads and Road Transport," by Mr. J. Cracroft Haller, county surveyor, Nottinghamshire. "The Problem of the Canals," by Sir John Eglesome, K.C.M.G., general manager, Aire and Calder Navigation, Leeds. On the second day, a visit will be paid to the Manchester Ship Canal, by special invitation of the directors, and additional visits to places of interest in the vicinity will be arranged. The Congress will be open to all corporate members, graduates and students of the Institute. A complete programme will shortly be issued, together with forms to be exchanged for the requisite Congress ticket and cards of invitation to social functions. Arrangements for the Congress are being carried out by a local committee, comprising Messrs. C. Bentham (H. Simon, Limited, Manchester, &c.); W. A. M'Grath, M.B.E. (Rochdale Canal Company); and R. C. Reynolds, O.B.E. (Bleachers' Association, Manchester). Secretariat: Mr. H. E. Blain, C.B.E., (hon. secretary of the Institute); Major H. Mattinson, (civil engineer, Manchester Tramways), and Mr. A. Watson, C.B.E. (general manager, Lancashire and Yorkshire Railway), hon. local secretaries. Local headquarters: Corporation Tramway Offices, 55, Piccadilly, Manchester. The offices of the Institute are 2 and 3, The Sanctuary, Westminster, S.W. 1.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Of late there has been a good deal of discussion in local coal trade circles in respect to export contracts over the ensuing year. So far, however, little actual business has been arranged, but it is freely reported that a number of contracts have been concluded on the basis of 90*s.* to 95*s.* per ton f.o.b., for delivery over the next six and twelve months. In practically all cases sellers have agreed to carry over quantities in arrears from running contracts, which in many cases were made at prices ranging between 70*s.* and 80*s.* This practice is known as "marrying" contracts, a proportion of the cargo being invoiced at the lower price and a part at the new price. Under this arrangement buyers get the benefit of their old contracts, which in many cases would have run out and the arrears cancelled. Business has also been concluded for steam smalls on the basis of 60*s.* to 65*s.* per ton f.o.b. With regard to current deliveries the foreign inquiry is somewhat curtailed, as buyers, in view of the coal strike, ordered supplies from America, and consequently are not now in pressing need of fresh supplies. The demand is, however, more than sufficient to absorb available supplies, as outputs are not yet back to pre-strike levels, and the quantity available for shipment is correspondingly reduced. Prices in the circumstances are erratic and dependent on the individual circumstances of collieries. On the whole, they are steady on the basis of 112*s.* 6*d.* for large, 102*s.* 6*d.* throughs and 95*s.* for smalls. A new issue of permits for the export of foreign cargo and bunkers has been made, under which the bunker allocations have been reduced to a third for the next fortnight and the cargo allocations correspondingly increased. The quantity of shipping in dock, which had accumulated during the period of the strike, is ample to meet the current need of shippers. In fact, there are sufficient boats already in dock to meet the requirements of exporters for the next 10 days at least. The result is that the inquiry for tonnage on the freight market is restricted, and with shipping freely offered rates have receded to the lowest levels touched this year. Rouen, for instance, has been done at 15*s.*, compared with the previous bottom rate of 17*s.* 6*d.*; Bordeaux at 20*s.*, against 18*s.*; Port Said 25*s.*, against 27*s.* 6*d.*; Gibraltar 17*s.* 6*d.* against 15*s.*; Havre 15*s.*, against 21*s.*; Genoa 27*s.* 6*d.*, against 22*s.* 6*d.*; and Boulogne 15*s.*, against 21*s.* It is expected that by the end of the week outputs should be restored to normal levels, and that there should be an improved demand for tonnage.

The Iron and Steel Trades.—Though the majority of South Wales works have resumed operations, work is not expected to be in full swing till early next week. With the industrial outlook brighter the markets displayed a steadier and more confident tone. The effect of American, French and Belgian competition is, however, having an influence on prices. America is stated to be offering tin plates at 2*s.* per box below Welsh prices and Germany at 1*s.* less than the American figure. Notwithstanding this, Welsh makers are for the time being standing out for 41*s.* for the basis box. Many orders, it is reported, have been lost to South Wales as a consequence of the coal strike.

THE INSTITUTE OF COSTS AND WORKS ACCOUNTANTS.—We are informed that arrangements have been made to hold the examinations in connection with this Institute on December 6 and 7, in London, Manchester, Birmingham, Glasgow and Sheffield. Forms of application and further particulars may be obtained from the Secretary, 38, Grosvenor Gardens, Victoria, S.W. 1.

SLIDE RULES.—We have received from the Cavendish Press, Cheam, Surrey, two special slide rules. Of these one gives by a single setting the Treasury rating of a motor car engine, and the other gives the proportions of helical springs, forming, in short, a compact substitute for an elaborate alignment chart. The scales cover a range of wire diameters from No. 16 gauge up to ½ in. diameter and any number of coils between 4 and 40.

DEMAND FOR AMERICAN MACHINERY ON THE CONTINENT.—Consul Ralph C. Busser, at Trieste, has sent a report to the Department of Commerce, says *The Iron Age*, New York, urging American manufacturers of machinery to organise their export business to compete in the portions of Italy, Jugoslavia and German-Austria tributary to that port. "It would be advisable," he says, "to study conditions on the spot and to form connections with good local technical or engineering firms which have the facilities for exhibiting, handling and installing American machinery. Ample stocks of machines would thus always be available for the prompt filling of orders and executing of contracts." The material chiefly in demand, continues the report, "includes electric apparatus and appliances, water meters, turbines, cranes, steam and oil engines, equipment for shipbuilding, mining and textile machinery. The steam and electric railways are also in great need of equipment and supplies. Jugoslavia, German-Austria, Hungary, and other countries of the hinterland are in need of locomotives and rolling-stock on account of the great losses and deterioration in consequence of the war. Among the new projects which will create a considerable demand for machinery, is the plan to connect up the hydro-electric plant of the Celina in the Veneto with the Isonzo plant at Monfalcone and the hydro-electric plant of the Recina with the hydro-electric plants of the Celina and the Isonzo. Plants especially in need of new equipment and machinery are textile mills in German-Austria and Jugoslavia; the coal mines of Istria and Dalmatia; the tramways of Trieste, Pola, and Gorizia, and the shipyards of Trieste and Monfalcone."

NOTICES OF MEETINGS.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday evening, November 13, at the Memorial Hall, Albert-square, Manchester. The evening will be reserved solely for an Address on "The Education Act of 1918, as it affects the Engineering Industry," by Mr. Spurley Hey, M.A., Director of Education, Manchester. The chair will be taken at 7 p.m.

THE BRADFORD ENGINEERING SOCIETY.—Monday, November 15, at 7.30 p.m., Meeting in the Hall of the Bradford Technical College. Mr. G. W. Cosby, of Leeds, on "Chain Driving," with lantern illustrations.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 16, at 5.30 p.m. Paper to be read, "Cross Connections on the Elan Aqueduct of the Birmingham Corporation Waterworks," by Mr. Frederic William Macaulay, M.Inst.C.E.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, November 16, at 5.30 p.m., at the House of the Royal Society of Arts, John-street, Adelphi. The following papers will be read: "Colloidal Fuel," by Mr. Lindon W. Bates, of New York; "Properties and characteristics of Colloidal Fuel," illustrated by lantern slide charts and cinematograph demonstration of the colloidal movement, by Mr. Haylett O'Neill, of New York. The chair will be taken by the president, Sir Frederick W. Black, K.C.B.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN, WEST MIDLANDS BRANCH.—Wednesday, November 17, at 7.45 p.m., at the Chamber of Commerce, New-street, Birmingham. Lecture by Mr. W. H. Davis. Subject, "Notable Bridges and Their Vicinities."

THE ROYAL SOCIETY OF ARTS.—Wednesday, November 17, at 8 p.m., Inaugural Address of the 167th session, "Wireless Telegraphy and Telephony," illustrated by experiments, by Mr. Alan A. Campbell Swinton, F.R.S., Chairman of the Council.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, November 17, at 6 p.m., a Special General Meeting of the society at 70, Victoria-street, Westminster. Business: (1) Proposed alteration of by-laws 13, 14, 15; (2) resolution authorising an issue of debentures to an amount not exceeding 8,000*l.* To be followed by an Ordinary Meeting. Papers to be read: (1) "The Clash of the Trades in the Pacific," by Mr. C. E. P. Brooks, M.Sc., F.R.Met.Soc., and Mr. H. W. Braby, M.A., F.R.Met.Soc.; (2) "Note on the Mirage, as Observed in Egypt," by Dr. W. H. Steavenson, F.R.A.S.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, November 18, at 5 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2, a paper entitled "The Problem of the Helicopter" will be read by M. Louis Dambiane, the chair being taken by Air Vice-Marshal Sir E. L. Ellington, K.C.B., C.M.G., C.B.E., the Director-General of Supply and Research.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 18, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Inaugural address by Mr. L. B. Atkinson, President, and presentation of premiums. The above meeting has been unavoidably postponed from the 11th, the date originally fixed. The meeting of the Wireless Section fixed for Wednesday, the 17th, has been postponed until November 24, at 6 p.m.

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Thursday, November 18, at 2.15 p.m., at the Queen's Hotel, Leeds. Paper, "Firedamp Explosions," by Mr. R. V. Wheeler, D.Sc.; Mr. R. Clive's paper, "Running Two Fans in Parallel at Bentley Colliery and other Ventilation Problems," will be open for discussion; Mr. T. S. Hayes' paper, "The Development of the Udi Coalfield in Southern Nigeria," will be open for discussion.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 19, at 7 p.m., at 39, Victoria-street, Annual General Meeting. Discussion, "Economical Transmission of Power." Opener, Mr. G. H. Ayres, A.M.I.Mech.E., Member.

THE FARADAY SOCIETY AND THE SHEFFIELD SECTION OF THE INSTITUTE OF METALS; JOINT MEETING.—Friday, November 19, a general discussion and symposium on "Electroplating" will be held at the Mappin Hall of the Department of Applied Science of the University of Sheffield, St. George's-square, at 3 p.m. and 7.30 p.m. The discussion will be presided over by Sir Robert Hadfield, Bart., F.R.S., and Professor C. H. Desch, D.Sc., Ph.D. The afternoon session will be devoted to the discussion of problems relating to electroplating generally, and the evening session to the consideration of papers on silver plating. Among the papers to be presented will be the following:—3 p.m.: "Electroplating for the Prevention of Corrosion," by Mr. Leslie Aitchison, D.Met., B.Sc.; "The Use of Colloids in Electro-deposition of Metals," by Mr. W. E. Hughes, B.A.; "The Electro-deposition of Cobalt," by Mr. Byron Carr. 7.30 p.m.: "Electro Silver-Plating and its Technical Development," by Mr. W. R. Barclay, A.M.I.E.E.; "The Chemical Composition of Old Silver-Plating Solutions, with Observations on their Working Properties," by Mr. G. B. Brook, F.I.C., and Mr. W. L. Holmes; "A New Maximum Current Density in Commercial Silver-Plating," by Mr. Frank Mason, A.M.I.E.E.; "The Crystalline Structure of Electro-deposited Silver," by Mr. G. B. Brook, F.I.C. Contributions to the discussion are invited from members unable to attend the meeting.

MESSRS. SCHNEIDER AND CO.'S NEW STEEL WORKS, BREUIL, NEAR CREUSOT.

(*For Description, see Page* 631.)

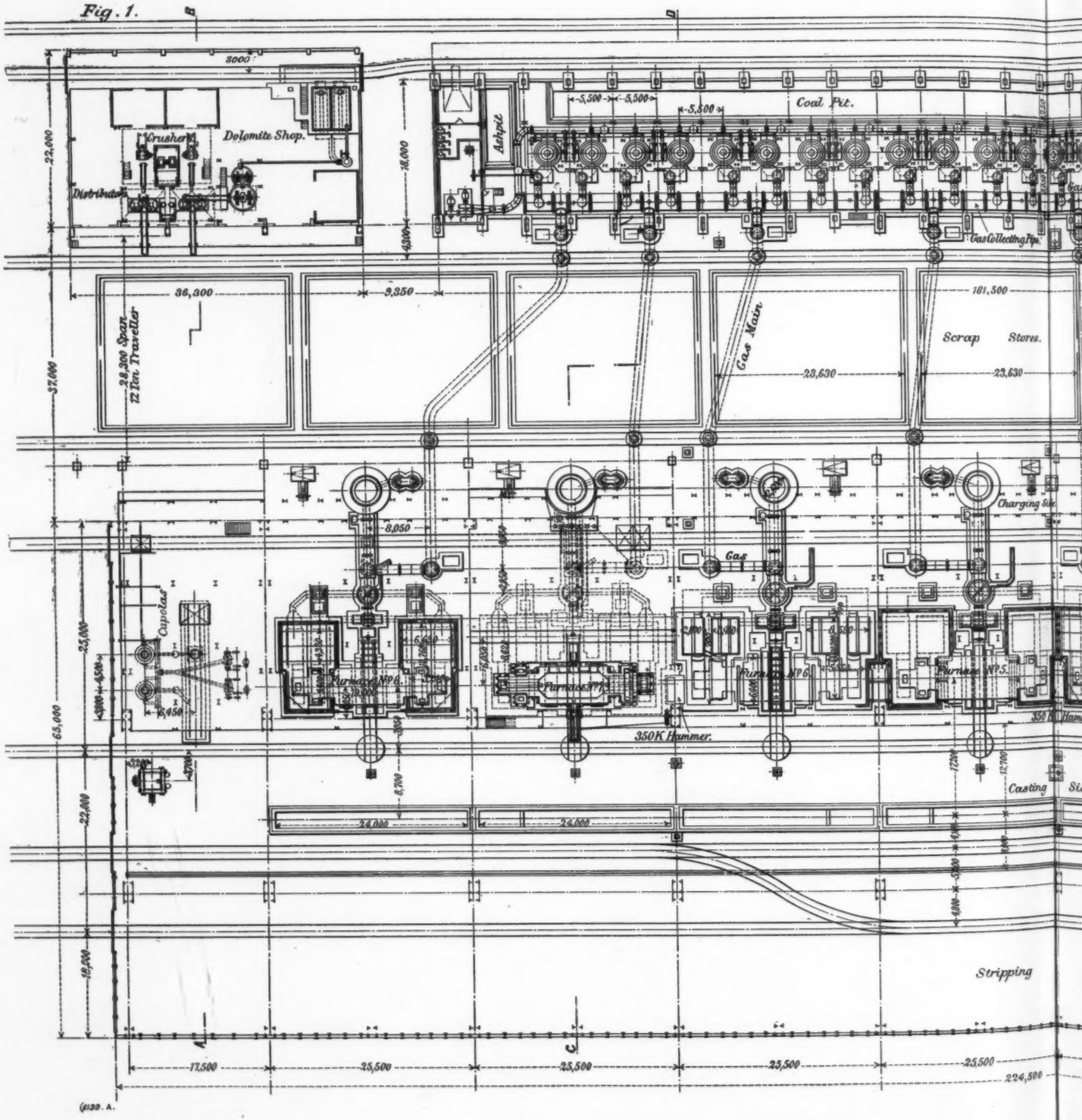
FIG. 7. OPEN-HEARTH FURNACES, CHARGING SIDE.

FIG. 8. OPEN-HEARTH FURNACES, CASTING SIDE.

MESSRS. SCHNEIDER AND CO.'S NEW STE

(For Description, see P

Fig. 1.



W STEEL WORKS, BREUIL, NEAR CREUSOT.

(Description, see Page 631.)

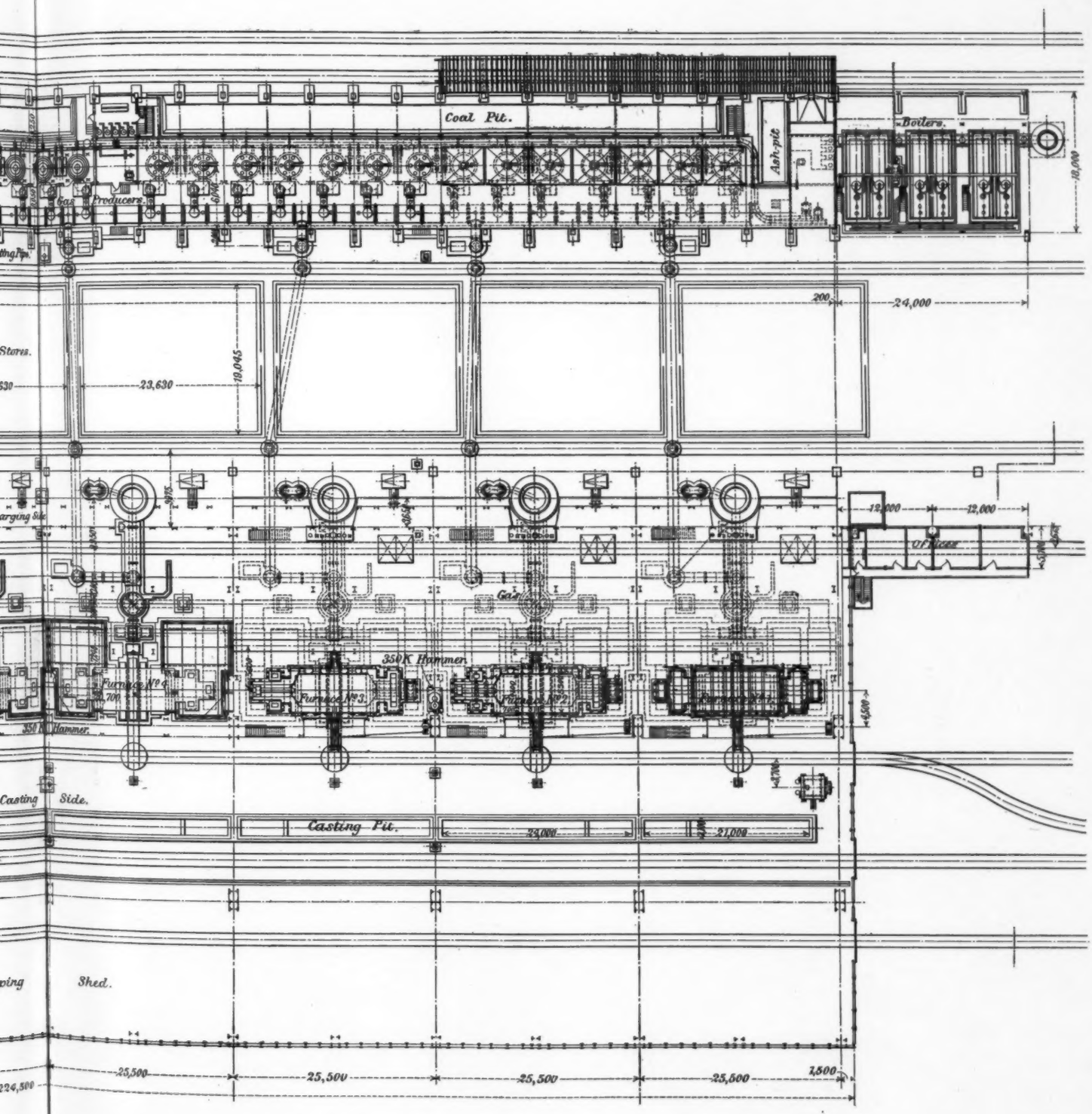


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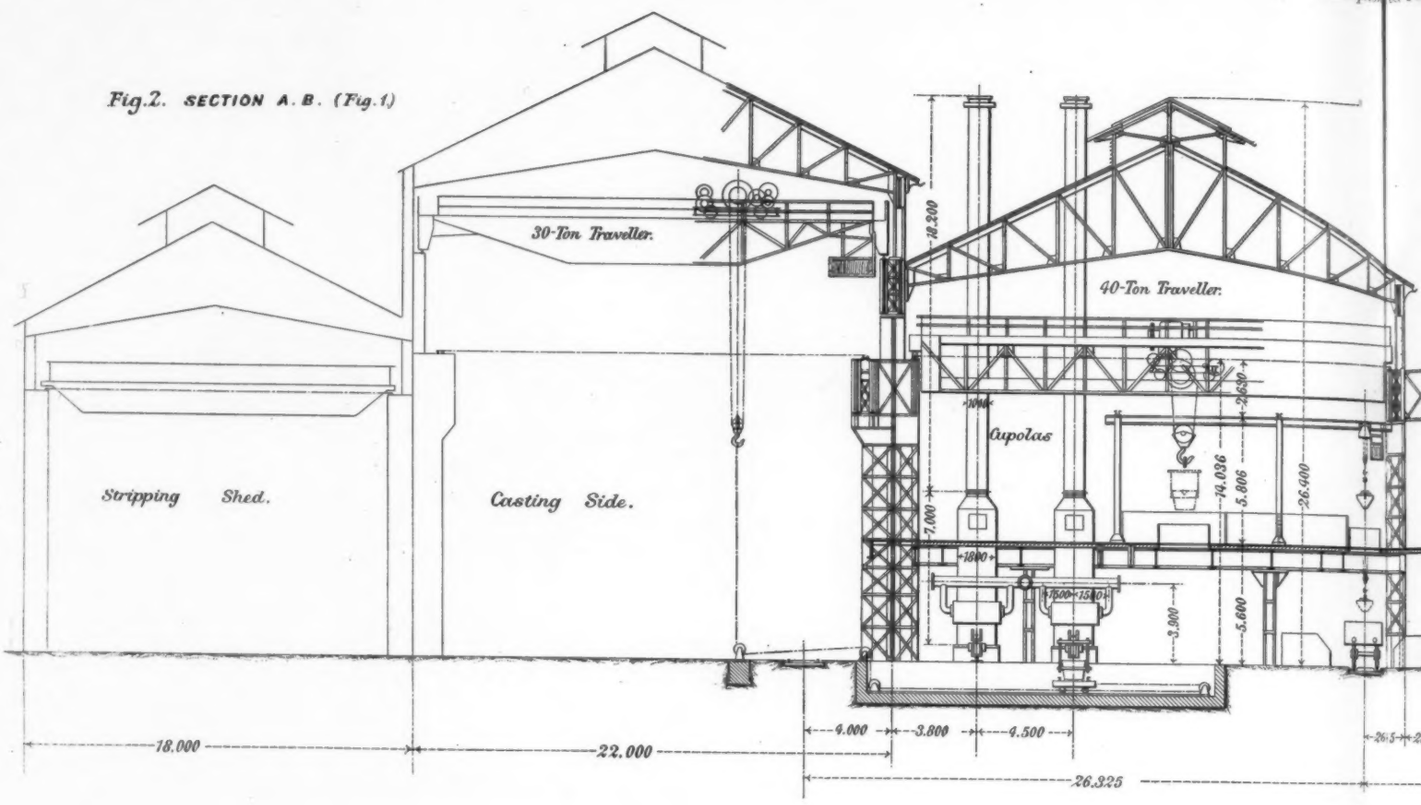
Fig. 2. SECTION A.B. (Fig. 1)



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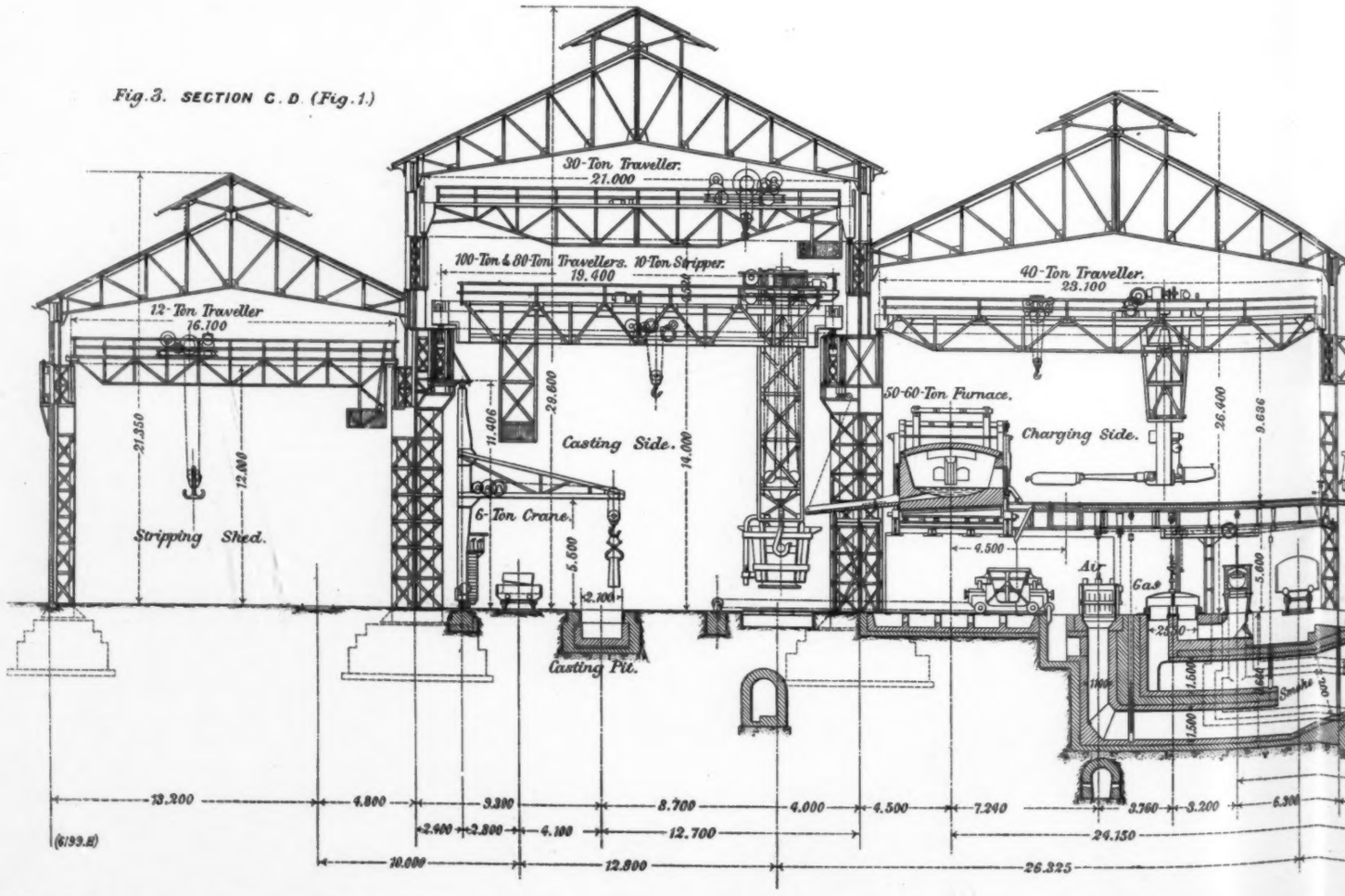

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W STEEL WORKS, BREUIL, NEAR CREUSOT.

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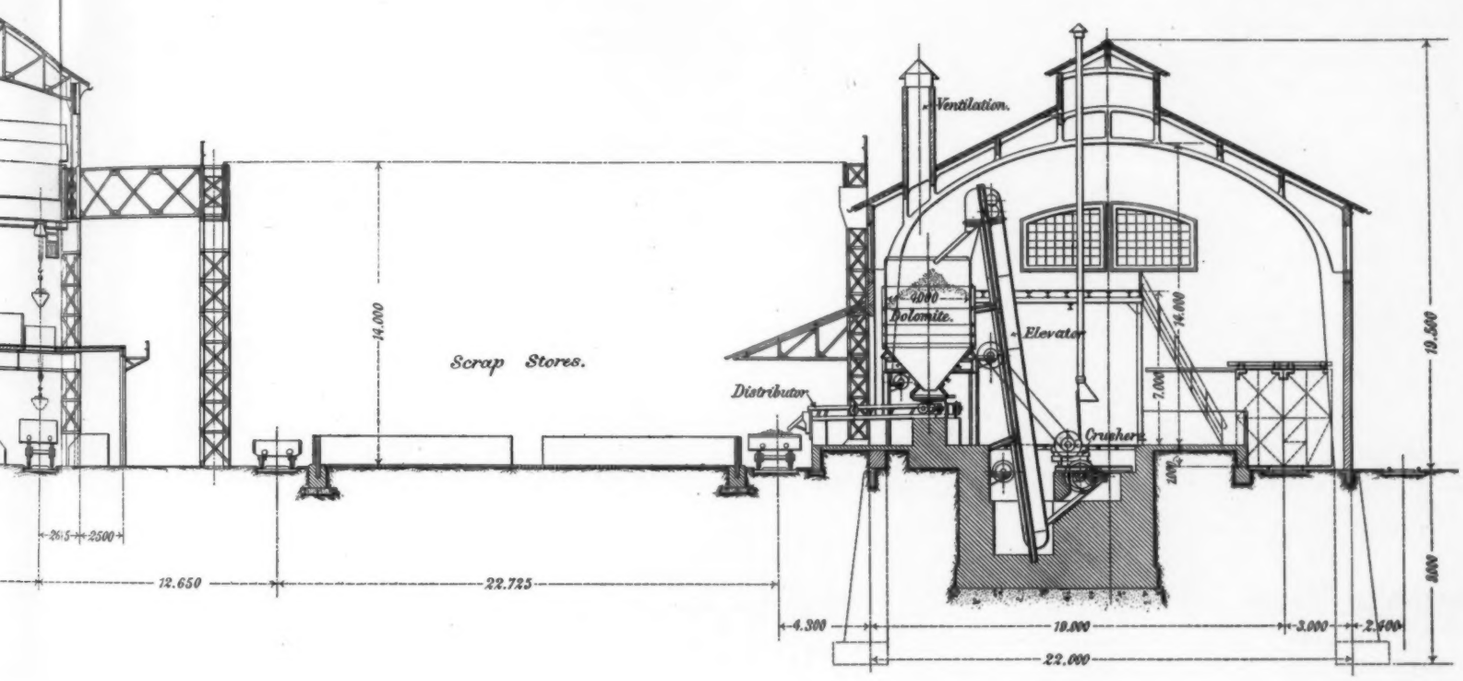

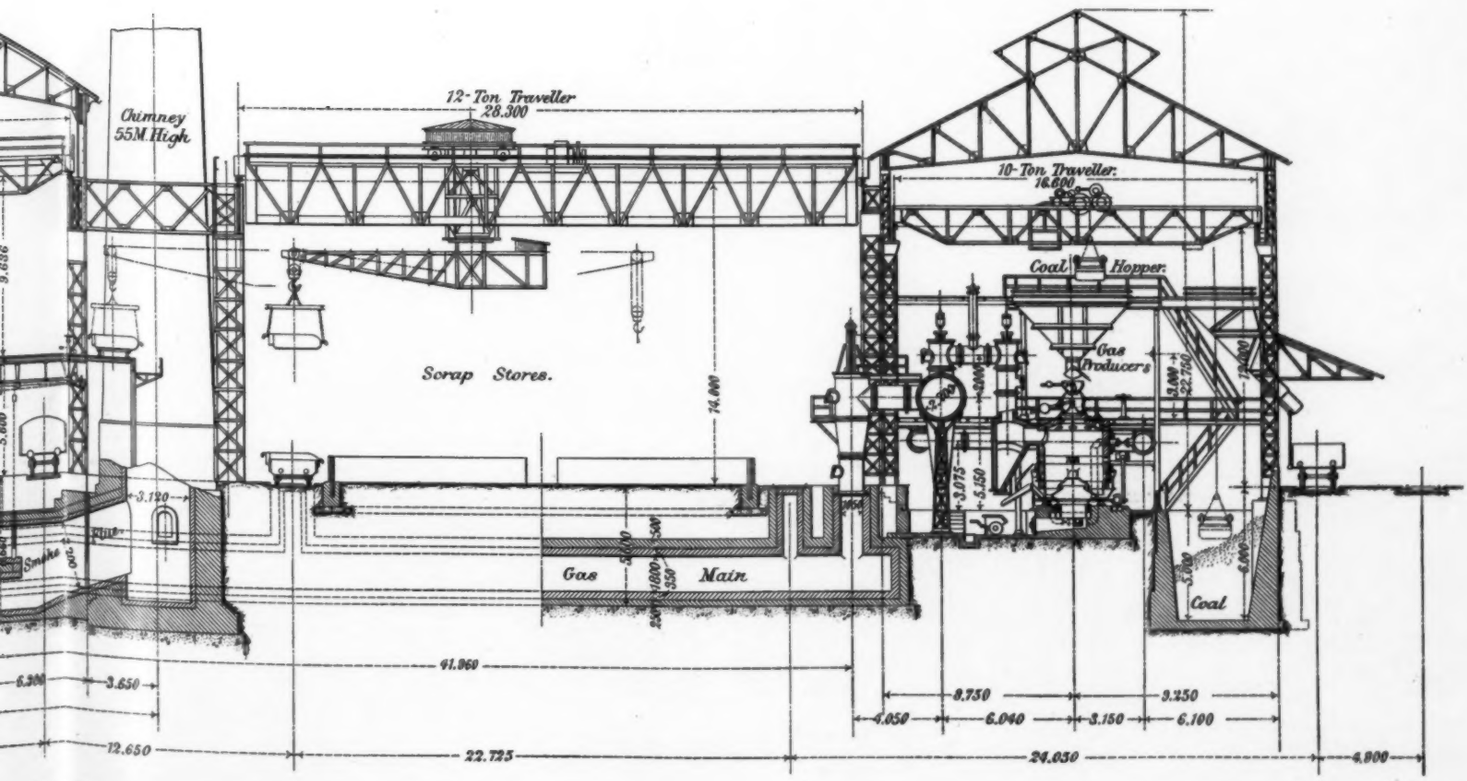

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3603 and 3598 GERRARD.

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With Two Two-Page Plates of MESSRS. SCHNEIDER AND CO.'S NEW STEEL WORKS, BREUIL, NEAR CREUSOT.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. As the postal rates have been again increased, the price of single copies sent by inland post is now 1s. 2½d.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 641.

DEATH.

CROFT.—On November 5, at "Draycombe," Morecambe, in his 64th year, Frederick Lister Croft, M.I.M.E., Governing Director of Crofts (Engineers), Ltd., Thornbury, Bradford.

ENGINEERING.

FRIDAY, NOVEMBER 12, 1920.

LIMIT GAUGES.

WHILST standard gauges have been in use for something like three-quarters of a century, the use of limit gauges, at any rate on a systematised plan in ordinary workshop practice, is of comparatively recent date. The standard gauges did undoubtedly prove of very great value, but necessitated considerable skill on the part of the operative. It is a common experience that a labourer cannot be trusted to measure diameters with callipers. He lacks the delicacy of touch which enables the highly-skilled gauge maker to distinguish by the feel between two bars differing from each other by as little as 1/50,000th in., as was proved by Messrs. Pratt and Whitney when they themselves took up this class of manufacture many decades ago. Naturally this degree of delicacy is not necessary in ordinary machine shop practice, but a skilled turner will reproduce the size of a standard gauge within a fraction of a mil, merely relying on the feel of his callipers. A novice, on the other hand, using the same tools, will commonly produce work several mils over size.

In America the supply of skilled mechanics has ever been short of the demand, and it has been necessary to make the most of it, and to execute much commercially accurate work by labour of somewhat indifferent quality. To this end the introduction of limit gauges has largely contributed. In the Thomas Hawksley lecture, delivered to the Institution of Mechanical Engineers on the 5th inst., Sir R. T. Glazebrook gave a quotation from Lieutenant-Colonel Peck, of the United States Army, which clearly sets forth the advantages of the system. To produce articles of good quality at a reasonable cost great ability and skill are required, and the use of gauges has been found, Colonel Peck states, "an admirable method of transferring the skill of a single good man to an entire organisation." Our own experiences during the war confirm this view in a very conclusive fashion. In every kind of repetition work, whether comparatively rough like shell-making, ordinary first-class work like machine-gun making, up to the precision work of screw-gauge making, it was found possible to train, with a few weeks' tuition, the ordinary average girl to produce work of the most satisfactory character, although it is a commonplace that the average woman is little interested in mechanism and machinery. In short, our war-time experiences suggest that provided the demand for a particular article be sufficient to make its production possible on the repetition system there is no class of work which cannot be successfully produced by unskilled labour. It is quite possible that were the demand for interference plates as great as that for gauges was during the war, means would be developed for transferring the skill of a Brashear to the girls who now do most of the bevelling of plate glass. In repetition work little demand is made on the mind of the operative, and it is his mental qualities which make the exceptional mechanic who can deal successfully with work offering in every variety, no two jobs being perhaps precisely alike.

Amongst the important matters touched on in his lecture, Sir Richard referred to the very important change which has recently been made by the British Engineering Standards Committee in the basis on which systems of limit gauges are to be founded. In 1906 this committee, after a careful review of the position as it then presented itself, recommend that shafts and spindles should be made as near as practicable to the nominal sizes and that the tolerances necessary should be provided in the holes and bushes. In thus deciding, the committee were probably much influenced by the steadily-growing use of bright drawn steel bars, which for many purposes can be used without machining. A great objection to this plan was that it was much easier to vary the size of a shaft than that of a hole and, moreover, it is much easier to adjust to different sizes external than internal gauges. In view of these and other considerations the committee last year decided that for the future the hole should be made as near to standard size as practicable and that the allowance should be made in the shaft.

The theory of lubrication shows that for running fits the allowance should not increase as rapidly as the diameter. In fact, if the allowance were proportional to the diameter, the conditions would be geometrically similar in large and in small bearings, and in that case the load carried per inch run of journal or bush length would be the same in the small as in the large bearing. This is not required, since it is impossible from considerations of strength and stiffness to impose the same load on a small journal as on a large one.

Practical experience confirms theory in this regard, and it has accordingly been common to make the limits vary according to a parabolic law. In Germany, according to Sir Richard, a rule is in vogue by which the allowance is made equal to $0{\cdot}00066\ k\ \sqrt{D}$, where D is the diameter in inches and k is a coefficient, the value of which depends on whether a running, push, or forced fit is required.

In this country it has been proposed to make the allowance vary according to the law represented by $a + b\ \sqrt{D}$ where a and b are coefficients. This rule seems distinctly less rational than the German, as it is impossible that a shall have the same value for small instrument work as for heavy machinery.

A question which the Engineering Standards Committee have not yet decided is whether the tolerances on holes should be all positive or be equally divided between the positive and negative sides. Inquiries made show that both systems are in use and to about the same extent. Advocates of the latter plan maintain that with it the holes on the average will be nearer standard than when the tolerance is wholly positive. This is no doubt true, but a still better result would be obtained if the positive tolerance were increased and the negative one diminished. An instructive curve showing the results of measurements on 79 crank pins, all made to limit gauges, was published in our issue of January 4, 1918. In this case equal positive and negative limits were allowed, each being equal to 0·0005 in., but from the curve it appeared that a closer fit to the standard would have been obtained had the limits been + ·00035 and − ·00065 in. Sir Richard Glazebrook strongly advocates, however, the plan of making all hole tolerances positive, and this is apparently what is approved in America and on the Continent. It has incidentally the advantage that the standard gauge is the "go" gauge. With regard to "not go" gauges Sir Richard emphasised the importance of Mr. Wm. Taylor's dictum that a "not go" gauge can only check one thing. In the case of screws, for example, it can check either pitch or diameter but not both, so that more "not go" gauges are required than "go" gauges. At the beginning of the war this was not recognised at Woolwich, who

had both a "go" and a "not go" gauge for screws. The uselessness of the latter was pointed out and it was accordingly discarded, thus reducing by one-half the number of gauges required.

For running fits it has been the practice to make the allowances vary with the diameter according to a parabolic law. For force fits Sir Richard states that there are sound reasons for holding that the allowance should be directly proportional to the diameter. Undoubtedly this is true for geometrically similar conditions. In practice, however, the thickness of the piece shrunk on, or into which a pin is forced, is frequently relatively greater, the smaller the diameter and the conditions of geometric similarity no longer apply. It must be remembered in this connection that Professor Bridgeman has shown that thick cylinders burst by internal pressure always fail at the exterior surface, and not at the interior, as is commonly assumed in the ordinary theory of their strength. Hence in shrunk fits the tensile stress at the internal surface is of relatively minor importance. What is needed there is a heavy radial pressure, giving by friction a firm grip on the shaft. The thicker the ring relatively to the spindle the less proportionately is the allowance necessary to develop this. From the foregoing consideration it would seem therefore unnecessary to make proportionately as large an allowance for force or shrunk fits, when the diameter is small, as when it is large.

In an appendix to his lecture Sir Richard Glazebrook gave a very interesting account of the method developed for testing screws optically. This method, which has already been fully described in our pages, consists in projecting a magnified image of the thread on to a screen and comparing it with a carefully drawn standard. The main difficulty was, we imagine, unanticipated, viz., to get the fiftyfold magnified image free from distortion. It took at the outset much experiment to get even an undistorted field of as much as 1¼ in. in diameter, but ultimately combinations of lenses were found giving an image free from distortion over a 7 ft. field and with reasonably good definition.

It is gratifying to note that Sir Richard Glazebrook was able to state that our manufacturers are now taking much interest in the production of high-grade work. Before the war gauges, micrometers, and precision screws were largely imported, and Sir Charles Parsons has stated that the inquiries of the Committee which investigated conditions on the North East Coast shortly after the outbreak of the war, showed that very few firms were equipped for executing really fine work, and that it was accordingly necessary to send men to the National Physical Laboratory for special training. Sir Richard Glazebrook now reports that the demand for precision work is such that Messrs. Taylor, Taylor and Hobson, of Leicester, are supplying commercially the floating micrometer screw diameter measuring machine, designed by them in conjunction with Mr. Turner, of the National Physical Laboratory, whilst Messrs. Cussons, of Manchester, are making commercially two patterns of pitch measuring machines.

SOME LESSONS OF THE MOTOR EXHIBITION.

For some years before the war the question of how to make the Motor Show satisfactory was a problem which had not been solved. Olympia was not large enough to accommodate all the firms who desired to exhibit, while the public patronised the show in such numbers that it was quite impossible for anyone who was interested technically in the cars to see anything or get any information. The show last year was no improvement on the pre-war ones.

This year, however, the show is divided into two parts, as in addition to the show at Olympia there is a section at the White City. This arrangement has obvious inconveniences, the more so as there does not appear to be any classification of the exhibits. Both places have large cars, small cars, tyres, accessories and exhibits of coach work. From the point of view of the public, as well as the exhibitors, it would appear that it should be a great improvement if the exhibits could be divided by some form of classification. Thus, at present, anyone waiting to look at one particular type of car, say a light two-seater, has to go to both places. If he has not time to do this he will go to Olympia, in all probability, and those exhibiting at the White City will be at a disadvantage.

It would apparently be far more convenient to the general public if large cars were shown at one place and small cars at the other. It would also be an improvement if all the exhibitors of coach work were at one of the places. Again, there seems no reason why accessories should not in some way be classified, all the tyre exhibits, and all the magneto exhibits, for instance, being together. There may be some practical objection to this, but there can be little doubt that it would be to the convenience of the public, and after all the whole motor trade depends on the public, and the more their convenience is considered the better it will be for the trade.

Generally speaking, from a technical point of view, there is very little new at the present show as compared with last year. Several of the English makers are in fact showing cars which differ very little from their pre-war patterns. Naturally, if a type of car has proved satisfactory, particularly under war conditions, there is great reluctance to go in for a new design. In other cases firms brought out a completely new design last year and are keeping to this. The increase in space due to the addition of the White City has allowed of a considerable increase in the number of exhibits, and there are therefore a good many fresh comers, both European and American, but these are mostly showing cars of very conventional types.

Taking the European, and more especially the English machines first, the same feature is apparent that has been noticeable for some time. A great many excellent vehicles are exhibited, but the majority of them are relatively heavy and expensive. In fact, the most striking point in the show is the number of makes of large expensive chassis. A very considerable number of makers are showing cars whose price will run over 2,000*l.*, with a weight, including a comfortable body, of from 35 cwt. to 40 cwt. This feature was apparent last year, when some makers who have made their name with small cars of comparatively low weight and price, were showing large expensive machines. This year there are still new comers in this class.

It is, of course, a purely commercial question whether or not this is a wise policy, and it may be that there is room for all these expensive machines, and that more profit may be made in selling a few large cars than a greater number of small ones. Even this seems doubtful, for the number of people who are at the present time prepared to spend very large sums on motors is probably not great, and the moderate-priced machine has improved so much of late years that there is not such a very great gain in having an extremely expensive one.

With regard to the smaller English cars we still find that they are as a rule on the heavy and expensive side. Thus the ordinary "light" two-seater weighs anything from 12 cwt. to 16 cwt., or from 6 cwt. to 8 cwt. per passenger carried. In some cases these cars are now made as four seaters, weighing apparently from 16 cwt. to 20 cwt. This brings the weight down to 4 cwt. to 5 cwt. per passenger, but as a rule the bodies are distinctly cramped and the engines very small for the work they have to do. The prices of these cars are generally in the neighbourhood of 500*l.*

Now a Ford weighs about 15 cwt., and carries five people, the weight therefore being 3 cwt. per passenger carried. It will also carry a considerable overload on occasion. The price is little more than half that of the "light car" of Europe. Besides the Ford there are a good many other American cars of quite moderate prices which have real five-seated bodies and weigh under 20 cwt. or 4 cwt. per passenger. It appears, therefore, that European makers should either be able to reduce their weight or price. A really cheap car, of course, cannot have the workmanship and materials in it that an expensive car has, and with better workmanship and materials weights should be reduced, not increased.

In the medium-priced cars, say at about 1,000*l.*, there is a distinct effort being made in some cases to save weight, though in others this seems to be regarded as a matter of little importance, and designs are very unnecessarily heavy. This matter of weight is really a very serious one, for the majority of running expenses depend on it. Of course, weight must not be cut down in a way to make the machine unreliable, but on the other hand unnecessary weight due to defective design actually makes a machine less reliable, as it may break itself to pieces owing to its own weight. This matter of price and weight is also a very serious question in regard to our export trade. Owing to duty, freight, &c., American cars are sold here at very high prices compared with their price in America. Hence the actual difference in price between the English and American car is not apparent. When we come to the question of export, however, the matter is very different, and we must face the fact that America produces quite a good range of cars with full-sized five-seated bodies and fairly large engines, at prices ranging from 300*l.* to 400*l.* Certain people decry these cars as being of very inferior quality, but the fact remains that in many cases they command high prices in the second-hand market here, even when four or five years old. In fact, many of them have changed hands lately at prices three times what their actual original cost was when new.

It is quite clear that at present we have nothing to compete seriously with these cars in foreign markets at equal prices, and it is also clear that it is most important both from the point of view of the trade and the country that we should develop our export trade. The matter of price, therefore, requires very serious consideration both on the part of the manufacturer and the Labour Party, from the latter probably even more than the former.

Coming to technical points the cars exhibited may be roughly divided into two classes, namely, first those with separate engine and gear-box units, second those in which these are combined. Previous to the war the usual European practice was to have a separate engine and gear-box with flexible joints between them, and these were very frequently carried on an underframe. A few makers developed combined units, but the very large majority had them separate. In America the combined unit was coming into use even at that time, and during the war it became practically universal. Among the modern European makes there are a great many which still keep to the separate units, and there are also a considerable number of new cars on the market in which this construction is adopted.

Excluding the very largest and highest priced cars for the moment, it does not appear at all clear what are the advantages of the separate unit construction. It is very difficult to make a motor-car frame really rigid, and therefore however carefully the engine and gear-box are lined up they will at times get more or less out of line, and it is for this reason usual to provide universal joints between them. On the other hand when the engine and gear-box are made one unit they are rigidly held in line, and no universal joints are needed. The latter should therefore result in the sweeter running machine of the two and the cheaper to keep up. In the matter of cost, the single unit has greater advantages still, for the erection of the separate engine and gear-box is a very expensive thing and further, usually needs a relatively expensive frame. On the other hand, the combined unit is bolted together on machined facings on the bench, and is usually carried on a three-points suspension. The erection on the frame therefore simply consists of bolting it up with three bolts.

It seems clear that the combined unit must become general for all those cars in which cheap construction and maintenance is of importance, and it is therefore not very encouraging to find that during the last two years a considerable number of new cars have been placed on the market by English makers who aim at competing in the class of the cheaper car, but who still go in for separate engine and gear-box, and very complicated framing to carry them. There may be good reason for an old established firm to keep to a well-tried pattern which has a good reputation and sale, but new firms should go more thoroughly into the

question of the manufacturing cost of their designs. In the largest and most expensive cars there may be some reason for the separate units, as both the engine and gear-box become very heavy units, and there may be therefore some advantage in having them separate. Even here, however, the balance of advantages appears to be with the combined unit, and it will probably become general. While a good many of the new firms are showing cars whose general lay-out is of the separate unit type there are also a good many of the old firms who have adopted the combined unit and produced what appear to be very good manufacturing designs, for instance, Talbot, Darracq, Panhard, Berliet, &c. There are also good examples among the new designs.

Among the American cars there is a considerable sameness. It appears to have become established practice to have an engine carried on a three-point suspension and to bolt the gear-box to the back of the engine by a circular flange. In some cases the back axle is controlled by a torque tube carried on a ball joint at the back of the gear box: in others the drive and torque are taken by the springs, while the propeller shaft has two universal joints. Both brakes are usually on the back hubs.

Coming to details; engines, both European and American, still show great diversity. There are numerous examples of four, six and eight-cylinder engines, the latter being usually diagonal, though there are examples of the eight-cylinder line. There is also one example of a 12-cylinder engine. The number of cylinders is also not proportionate to the size or price of the car, for there are examples of quite small and relatively cheap six-cylinder cars and also of large, expensive four-cylinder. Time alone can tell which of these will become general, but the tendency appears to be towards the six or eight-cylinder types.

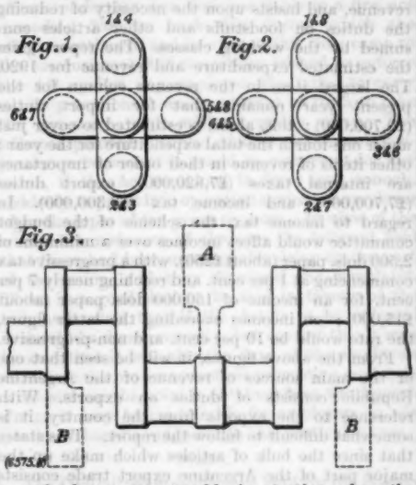
Valve arrangements are still very varied. There is a distinct tendency towards the overhead valve, though many makers stick to the valve at the side. Both the valve arrangement and the number of cylinders may be affected by the rating for taxation. This is, as is well known, based solely on the area of the cylinders. We have previously expressed our opinion on this rating and on the evil effects it is likely to have on car construction. It is obviously hopelessly unscientific, as it assumes that an engine would give the same power whatever the stroke or even if it had no stroke at all.

To see the probable effects of the rule, it is necessary to consider a few of the ascertained facts. The power it is possible to get out of an engine is proportionate to the cubic contents of the cylinders, i.e., area multiplied by stroke. Hence the longer the stroke the greater the power that can be obtained from a given area, and therefore a given tax. There is a limit to the stroke in practical motor-car engine design, but up to this limit the rule holds good. The practicable stroke-bore ratio is about the same whatever the number of cylinders in the engine; hence the greater the number of cylinders the smaller the power per unit of rating for tax. This may prevent the advantages of the smaller-sized multi-cylinder engines being brought into general use here. The endeavour to get the greatest possible power out of small cylinders to reduce the tax may also have an effect on the valve arrangement. Overhead valves will undoubtedly give slightly more power per unit of cylinder size, though they do not necessarily reduce the weight of the engine per horse-power. In fact, the whole tendency of the tax will be to produce an engine with cylinders of small diameter and long stroke running at a very high rate of speed. Such an engine is by no means light per horse-power, as the crankshaft, crank-case, &c., have to be very heavy owing to the inertia forces. In fact, such an engine is inferior from every practical point of view to one of more reasonable proportions, but there is a certain section of the public who would rather spend 20*l.* a year in extra upkeep than 5*l.* in extra tax, and therefore the inferior engine may very likely come into use.

In this case the overhead camshaft may become popular. There are some decided disadvantages in this, but it enables the moving parts of the valve gear to be made very light, and this is an advantage at very high speeds.

In details, engines are now generally well designed, but there are two points which appear to need consideration. One is the drive of the dynamo. Electric light and self-starting appliances are practically universal, and therefore a dynamo is necessary, but in a very large number of English cars this is driven by a belt while in American practice it is usually gear-driven. The latter appears to be distinctly the better arrangement as belts stretch and get unreliable. In many cases the same belt drives the fan and dynamo, in which case it has a very small arc of contact with the pulley, and the probability of trouble resulting is likely to be greater.

Another point of interest is the ignition. In America the usual ignition is by coil and distributor from the same battery as the electric light, &c. In England a magneto is usual, and many of the American cars imported are specially fitted with magnetos for the English market. Now the speed at which the ordinary self-starter turns the engine is usually much lower than that at which it is turned when started by hand. Further, the self-starter usually slows distinctly when turning over the compression, while the hand instinctively gives a jerk. The result is that the speed at the moment of break of the contact breaker is very much lower with the self-starter than it is when starting by hand. This



may lead to great trouble in starting when the magneto and starter have been in use for some time.

This trouble could, of course, be entirely overcome if the magneto were fitted with "impulse" starters as in these the magneto is flicked over the period of break with a spring, and the spark is quite independent of the speed; but very few cars are so fitted, though the majority of the magneto makers show such starters.

Two examples of eight-cylinder vertical engines are shown, and it is interesting to note that the cranks are arranged differently. It is, of course, necessary to have four of the cranks at right angles to the other four in order to get even firing. In the one engine the four cranks at one end of the engine are at right angles to the four at the other end, as Fig. 1. In the other the four middle cranks are together and the two front and back ones at right angles, as shown in Fig. 2, these figures viewing the crank from in front, the cranks being numbered from front to back. The second arrangement appears theoretically to be a good deal the better. In the first place it is impossible to perfectly balance a four-cylinder vertical engine, and Fig. 1 represents essentially two four-cylinder engines in line, and therefore there will be a rocking moment between them. Fig. 2, on the other hand, represents a four-cylinder engine in the middle with another four-cylinder engine put half at each end of it, and is therefore practically perfectly balanced. In addition to this there is a considerable variation in the kinetic energy of the reciprocating parts of a four-cylinder engine at different parts of the stroke. The result is considerable torsional stresses on the crankshaft at high speeds, and these are likely to be considerably greater in Fig. 1 than in Fig. 2. A considerable number of two-bearing four-cylinder engines are shown, but it is surprising how few of these are fitted with balance weights to the crankshaft. The four-cylinder crankshaft requires no balance weights to balance it as a whole, but if unbalanced there is a very heavy bending stress due to the centrifugal and inertia forces of the middle crank pins and inertia forces of the pistons at high engine speeds. By fitting balance weights as shown diagrammatically in Fig. 3 these stresses can be much reduced, and the wear of the main bearings due to distortion of the shaft eliminated. The full lines show usual crank construction and dotted lines the balance weights. The balance weight A reduces the bending moment in the centre part of the crank, and this is balanced by the smaller balance weights B, B.

With regard to chassis construction there is not a great deal of change. Frame construction is in many cases simplified, and there is a distinct tendency to adopt the tapered frame, i.e., nearly straight side members a good deal wider apart at the back than in front. This seems a distinct advance. Few frames are fitted with really substantial torsion members. An exception to this is the Lanchester, which has a large tubular cross-member, the tube being about 6 in. diameter. There seems no reason why frames should not be made fairly rigid in torsion as springs are now long and flexible, and it should not be necessary for the frame to distort and help the springs. A rigid, frame undoubtedly very much helps to keep the body from squeaking.

Cantilever springs are gaining ground somewhat, and there is a very distinct tendency to adopt the quarter-elliptic or costermonger spring in the smaller sizes. This type is very simple and cheap, and if of good length should be quite satisfactory, while its adoption shortens the frame considerably. Back axles show little change. The bevel gear, usually of the spiral type, is universal in the American cars and general in European, though there are a certain number of worm-driven ones.

Three speeds are universal on the American cars, and appear to be gaining ground here, though many cars are still fitted with four. With the power provided for the modern car three speeds appear to be ample, and four to entail unnecessary gear changing. In this connection it seems a great pity that all European makers do not adopt a standard gate for their cars. For all practical purposes all American cars have the same arrangement of the speeds, and therefore anyone getting on to a new American car knows in what position to put the lever for any one of the speeds. European cars, on the other hand, have every possible arrangement of the speeds, and in many cases these have been arranged without any apparent thought being taken for the convenience of the driver. As the American arrangement is used on so many cars coming from that country, it appears that all three-speed cars should be made to conform to it, especially as it is the most convenient arrangement for the driver, the lever being in the outside back notch in the top gear, and therefore most out of the way of the drivers' legs in its usual position. If European makers are going to continue the four-speed car they should, however, arrive at a standard arrangement of the gate.

Gear boxes are now being made much more compact than they used to be, with a corresponding reduction in weight. This is mainly due to a reduction in the diameter of the gear wheels. A very remarkably small gear-box is the one on the Bianchi car. Probably this reduction in the sizes of gear wheels to transmit a given power is largely due to improved qualities of steel, though it may be partly due to the fact that a very large part of the running is now done on the top speed, and therefore the change-speeds are little used.

Taking it all round there is not a great deal of change since last year, but there is no doubt a general improvement. As far as the English cars are concerned what appears to be most required in the near future is a real study of manufacturing conditions and a really careful study of the essentials of a design cheap to make. Up to date it appears to have been thought in England that in the production of a cheap car design mattered very little, and that all that was wanted was a design which would work satisfactorily combined with good manufacturing methods. This is not so, and if we

are to compete with the American in the production of a cheap and satisfactory car the design must receive the most careful consideration from the manufacturing point of view. Anyone of competent manufacturing experience who will study some of the English cars will see that it would be possible with careful design to eliminate a very large amount of work without in any way reducing the value of the car to the user when it was made, and this end should be secured.

The question of weight also deserves more attention than it now receives, especially in the two-seated class. There are, as previously mentioned, several cars which will carry five people and weigh well under a ton, and therefore it should be possible to have a two-seated car weighing some 8 cwt. or less, but the supply of these is extremely limited, and there is nothing really so satisfactory as the larger light cars.

A point of importance which is only just beginning to receive attention is the adjustment of the wheel to suit different bodies, or even individual drivers. Generally speaking, the wheel and pedals of cars have been practically fixed, though some makers have made the pedals adjustable, and most firms have two or more standard rakes for the steering to suit different types of body. A very few have made the rakes of the steering anafts adjustable. It appears to be time now that both the steering gear and all controls should be made quite easily adjustable, and that the steering wheel at all events should be made adjustable from the driving seat. One maker at least provides a wheel the rake of which can be adjusted from the seat and, if necessary, when the car is running. Combined with this a sliding seat is provided so that the driving position can be anything desired.

There seems no reason why something of this sort should not be universal. After all, the car exists for the owner not the owner for the car, and the comfort of the former should be studied in every way. No two people like exactly the same driving position, and even the same person may desire to vary it at different times. A slight change of position is quite a relief on a long drive, and in cold weather, when thick clothes are worn, it is not convenient to get into the driving seat with the wheel in the best position for driving.

The lubrication of the various small details of the chassis is also receiving much more attention than formerly. There is usually a great deal of unnecessary wear in the shackle pins, steering joints, &c., from these being imperfectly lubricated. True, grease cups are often provided, but these take a great deal of time to attend to properly. In some of the larger cars arrangements are made to supply all these parts with oil by pipes from some central source of supply. If well carried out this should be a great improvement but, unfortunately, it is expensive. Oil-less bushes would seem to be the best arrangement for many parts if these can be made satisfactory. Every effort should, however, be made to reduce the number of small parts needing lubrication, and in this connection the general use of fabric universal joints appears to be a good move.

TRADE WITH THE ARGENTINE REPUBLIC.

In an article on the position of Brazil before the war and at the present time, on page 284 *ante*, we called attention to the wealth of that country, especially in mineral deposits, and stated the fact that it possessed almost unlimited water power resources. We also remarked that Brazil was among the countries that had benefited commercially and financially by reason of the war.

The situation in regard to the Argentine Republic and the effect of the war on the latter country are, to some extent, different. Argentina, in the words of Mr. H. O. Blackley, Commercial Secretary to H.M. Legation, Buenos Ayres, (Department of Overseas Trade, Report Cmd. 895), is still essentially a pastural and agricultural country, which lacks iron, coal, and water power; these conditions, coupled with unwillingness to risk capital in industrial enterprise and with the scarcity of skilled hands, have retarded the growth of manufactures in the Argentine Republic. Dealing with the effect of the war on this latter country, the next-door neighbour of Brazil, we find that the imports of coal—by far the largest item of imports previous to the war—amounted in 1913 to a total value of £5,664,790, in which figure the coal imports from the United Kingdom entered for £5,568,710. In the year 1917, the total value of the coal imported fell to £990,790, the figure for the United Kingdom entering in that total for £532,520. The total coal imports for 1918 represented a value of £1,150,760, and for the first six months of 1919 a value of £489,380. Generally speaking, the imports into Argentina of all other commodities show a falling off to a similar degree by reason of the war, except in the case of some articles which are received from neighbouring South American Republics or from the United States.

The report above referred to states that the budget committee of Argentina has called attention to the deficiencies of that country's system of taxation, a system which is based largely on Customs receipts from imports and exports, a situation which had led to a disorganisation of the national finances on account of restricted trade during the war. For this reason, it is added, the budget committee welcomes the Government's Income Tax project as a first measure towards reforming the existing system of revenue, and insists upon the necessity of reducing the duties on foodstuffs and other articles consumed by the working classes. The report gives the estimated expenditure and revenue for 1920. The largest item in the revenue column for the present year remains that for import duties (£9,700,000); this, alone, is estimated to cover just under one-fourth the total expenditure for the year; other items of revenue in their order of importance are internal taxes (£7,820,000), export duties (£7,700,000), and income tax (£3,300,000). In regard to income tax, the scheme of the budget committee would affect incomes over a minimum of 2,500 dols. paper (about £250), with a progressive tax commencing at 1 per cent. and reaching nearly 7 per cent. for an income of 150,000 dols. paper (about £15,000); on incomes exceeding the latter figure, the rate would be 10 per cent. and non-progressive.

From the above figures, it will be seen that one of the main sources of revenue of the Argentine Republic consists of duties on exports. With reference to the exports from the country, it is somewhat difficult to follow the report. This states that since the bulk of articles which make up the major part of the Argentine export trade consists of foodstuffs (meat, grain and dairy products) and of raw materials of prime necessity (wool, hides and quebracho), the trade was not seriously handicapped by the war or by restrictions of Allied Governments, the trade cut off from Germany being readily absorbed by the greater demands from Allied countries; the report adds that the export of all classes of produce was naturally rendered more difficult and expensive in regard to ship space and freights, but nevertheless it was effected. It adds also that the marked increase in the value of the Argentine export trade which occurred during the war, and particularly during the years 1918 and 1919, was due rather to higher prices than to the export of greater quantities of produce. From the point of view of exports and of revenue on exports, the country has not, therefore, suffered so much from the war as one would be led to believe at first glance. The following figures taken from the report are interesting in this connection:—

Year.	Total Exports in Value.	Animal Products.	Agricultural Products.	Forestal Products.
	£	Per cent.	Per cent.	Per cent.
1913 ..	103,831,300	38·7	58·1	2·0
1914 ..	80,626,300	49·3	47·4	2·3
1915 ..	116,435,850	40·3	54·8	3·2
1916 ..	114,599,900	51·6	42·9	3·9
1917 ..	110,084,000	68·3	26·3	3·2
1918 ..	160,293,200	62·5	32·3	1·9
Six months, 1919	68,365,900	66·4	29·4	2·2

The above values would appear to illustrate two facts, the first that, in regard to values realised by the exports, the Argentine Republic has benefited, rather than suffered, by the war and, in the second place, that, still from the point of view of values, the export of animal products is now two-thirds of the total value of the exports, instead of 38·7 per cent. in 1913, whilst grain and other agricultural products have receded from 58·1 per cent. to 29·4 per cent. of the total export value. A comparison with the quantities of exports is difficult to make, but we may give the following selection of figures taken from the report:—

Commodity.	1913.	1917.	1918.	Nine Months, 1919.
Maize, tons	4,806,951	934,539	666,411	1,709,978
Wheat, tons	2,812,149	935,828	2,996,408	2,037,521
Frozen beef, tons ..	332,054	355,841	494,069	291,870
Oats, tons	889,744	271,713	542,097	150,959
Flour, tons	124,649	111,465	176,444	251,647
Cattle, number ..	224,911	71,355	172,551	62,661
Canned meat, tons ..	12,574	100,784	191,000	111,607
Cheese, tons	7	2,728	6,430	7,169

We learn from the same source that one of the factors which has had the most influence on the economic situation of Argentina is the cessation of foreign capital, which was regularly invested in the Republic in increasing volume every year, previous to 1914, entailing a movement of materials, machinery and manufactured goods particularly from the United Kingdom. It is some satisfaction to note that the place of the United Kingdom as the source of such capital has not been taken by any other country. In consequence, however, of the cessation during the war of capital investment from the outside, railway construction, public works and other development schemes on a large scale have been suspended, entailing a considerable quantitative reduction, which still continues, of the Argentine import trade.

It is to be hoped that we shall soon be able to renew an active business intercourse with Argentina and to ship to that country the coal which she requires, together with textiles, railway material, locomotives, various iron and steel manufactured products, in all of which our figures were predominant before the war, Argentina being in a premier position to exchange for these a quantity of natural products, food mainly, of which we ourselves stand in need. This active intercourse being re-established, capital and credit would be forthcoming, enabling the Republic to carry out the various public works schemes planned, some of which are referred to by Mr. Blackley.

NOTES.

The Position of British Trade.

How easily it is possible to make entirely misleading deductions from statistics which are themselves quite accurate is strikingly demonstrated by some figures recently published in *The Board of Trade Journal*, referring to British trade in the quarter ended September last. In that period the declared value of exports of produce of the United Kingdom amounted to 369,811,000*l.*, and the fact that this figure shows an increase of nearly 180 per cent. over that for the corresponding quarter of 1913 (viz., 133,701,000*l.*), might be taken to indicate a similar increase in industrial activity. Such an assumption would, however, be quite erroneous. In order to determine the position with reasonable accuracy, it is necessary to take into consideration the increases in values of the various goods which have occurred since 1913, and to allow for these in making the comparison. It is obviously a laborious task to examine the current export statistics and assign to each item its corresponding value in 1913, especially as in the meantime considerable change has taken place in the character of some of the exported goods. Making reasonable estimates in the latter cases, however, the figure arrived at for the total value of British goods exported in the September quarter of this year calculated on the values of the individual items in 1913, is 98,351,000*l.*, which is thus 25·7 per cent. lower than the actual figure for the September quarter of 1913. The conditions with regard to imports are very similar to those explained above in connection with exports. The declared total value of imports for the last September quarter was 467,856,000*l.*, which is 161 per cent. greater than the value (179,021,000*l.*) of goods imported in the September quarter of 1913, but when pre-war values

are used for current imports, the former figure is reduced to 162,141,000*l.*—9·4 per cent. less than the actual figure for 1913. The calculated figures cannot, of course, be said to be exactly accurate, but they undoubtedly form a much more reasonable basis for comparing the industrial position than do declared values alone.

British Shipping and Shipbuilding during the War.

Statistics now available in the recently issued Annual Statement of the Navigation and Shipping of the United Kingdom for 1918, throw an interesting light on the effect of the war on British merchant shipping and shipbuilding, since comparative figures are also given for the years 1914 to 1917 inclusive. It appears that, in 1914, 326,900 vessels, with an aggregate net tonnage of 154,098,175, arrived with cargoes and in ballast at ports in the United Kingdom from foreign countries, British possessions and coastwise. In the following year the number of vessels arriving had been reduced to 247,166, and the net tonnage to 112,763,000, in round numbers, while in 1915 a further reduction to 216,699 vessels and 97,972,000 net tons took place. For the two last years of the war the corresponding figures were 178,220 arrivals (74,483,000 tons) and 160,617 arrivals (63,785,000 tons), so that, in 1918, the number of arrivals was less than half that for 1914 and the tonnage had been reduced by nearly 60 per cent. The figures for departures, of course, show a similar reduction, but they are in all cases somewhat lower. In 1914 the total number of vessels registered under Part I of the Merchant Shipping Act (1894) was increased by 133 and the net tonnage by 292,823, but in the following year, although the tonnage showed an increase of 14,282, the number of vessels registered was decreased by 266. In 1916 the net deductions amounted to 705, and the tonnage decreased by 674,175, but the result of the increased activity of enemy submarines was most seriously felt in 1917. In that year, in spite of the fact that 779 vessels, with a total net tonnage of 1,279,096, were added to the registers, the net deductions amounted to 1,349 vessels and the tonnage registered was reduced by 1,517,035. By the last year of the war the anti-submarine measures adopted by the Navy had evidently become much more effective, since, in that year, although the tonnage added to the registers was but little more than in the previous year, the net deductions were considerably less, amounting to only 528 vessels with a total net tonnage of 129,954. The figures for mercantile shipbuilding during the war period may also be included here, since they show the extent to which this industry was at first allowed to fall off, and later had to be speeded up in order to cope with the submarine menace. The vessels built in the United Kingdom in 1914 numbered 1,010, and had a total net tonnage of 838,608, while, in the following year, the number constructed was only 522, and the total tonnage amounted to only 374,446. In the three following years the number of vessels built decreased in each case, the figures being 479 in 1916, 397 in 1917 and 320 in 1918, but the net tonnages for the three years were 386,315, 752,120 and 820,884, respectively, showing that the average size of vessels built was greatly increased during the period. The actual figures for the average net tonnage of all mercantile vessels built in this country during the five years 1914 to 1918 inclusive, are 830, 717, 807, 1,895 and 2,565, respectively.

The Restoration of Pre-War Practices Act, 1919.

The Local Munitions Tribunal at Glasgow has issued a judgment in a prosecution under this Act which, if it is sustained on appeal, should free employers in Scotland from the prospect of further prosecutions under the Act unless in exceptional cases. The Act was passed on August 15, 1919, and its effect, stated broadly, was to place employers who had departed during and in consequence of the war from the observance of trade practices in their works under obligation, from October 15, 1919, to restore the trade practices and continue to conform to them for a year after the date of the restoration. It appears from the tribunal's judgment, that on September 15, 1920, the district representative of the Amalgamated Society of Wood-cutting Machinists gave notice in statutory form to Messrs. James B. Fraser and Co., Limited, timber merchants and packing-box makers, Glasgow, that the union were about to institute proceedings against the company in respect that the company had introduced female labour into their works during the war, for the making of packing-boxes, and had failed, notwithstanding the terms of the Act, to restore the pre-war practice of employing male labour on the work. It will be observed that although the statutory obligation to restore came into force on October 15, 1919, the union took no steps to enforce restoration until September 15, 1920—eleven months later—and no satisfactory explanation of the delay appears to have been given. The defendants pleaded that there had been unreasonable delay on the part of the union in raising the proceedings, and maintained that it could never have been intended that the Act should be kept hanging over the heads of employers indefinitely. On the other hand, the union maintained that so long as the Act remained on the Statute Book proceedings to enforce it could be brought at any time. The tribunal pointed out that any employer failing to comply with the statutory obligation to restore was guilty of an offence under the Act, and was liable to a fine not exceeding 25*l.* for each day during which the offence continued, and in view of this they came to the conclusion that if the unions wished to enforce the Act against any employer who failed to carry out its provisions it was incumbent on them to take the necessary steps without undue delay. The tribunal pointed out, also, that if the union's contention were correct it would be competent for any union, if the Act remained in force long enough, suddenly to put it into operation against an employer after the lapse of ten years or more. In view of the whole circumstances of the case the tribunal held that there had been unreasonable delay on the part of the union, and they dismissed the complaint. There is a good deal to be said in favour of the tribunal's view that if the Act is to be enforced it should be done promptly, but against this it may be said that it was also the duty of the employers to restore the pre-war practices promptly; and until a decision on the point is obtained from the Appeals Judge it may be inadvisable for employers to rely on the tribunal's judgment in this particular case.

Steel.

The Committee appointed in 1915 by the Society of Motor Manufacturers and Traders and the Institution of Automobile Engineers to investigate the properties of steel have now issued their report, which will undoubtedly prove of the utmost interest and value. The Committee included representatives of the Admiralty and some other government departments, and of the Institution of Mechanical Engineers, the Iron and Steel Institute and other technical societies, but the actual research was conducted by a sub-committee of seven, of which Mr. A. A. Remington acted as chairman till the completion of the tests, and subsequently this office was held by Mr. J. H. S. Dickenson. The programme called for the thorough examination of twenty different varieties of steel. In all cases specimens of the steel 1¼-in. in diameter, were heat treated and tested, but a number of tests were also made with specimens of a different size so as to disclose any mass effect. The heat treatment given varied with the nature of the steel, but in addition to normalised specimens tests were in most cases made also with oil and water-hardened bars subsequently tempered at different temperatures. The mechanical tests made included tensile tests, Brinell tests and notched bar tests. The work involved in carrying through this extensive programme was done by Mr. F. W. Harbord, Dr. J. E. Stead, Mr. N. S. Brayshaw, Prof. C. A. Edwards, the National Physical Laboratory, the Sheffield testing works, the Amalgams Company, Ltd., the Aeronautical Inspection Department, the Royal Technical College, the Royal Aircraft Establishment and Messrs. D. Kirkaldy and Son. The reports received from these different investigators, on steel which had nominally received the same treatment, showed in some cases considerable discrepancies, and the Committee have, in such cases, added to the observed results a "weighted mean" result deduced by themselves by a careful collation of all the tests. The steels investigated included both carbon and alloy steels and the report contains not only complete tables of the results observed, but also a series of curves plotted from the "weighted means" which show at a glance how the properties of the steel change with variations in its treatment. The effect of the heat treatment seems to be particularly marked in the case of some of the alloy steels. Thus, a "3 per cent." nickel steel containing ·37 carbon and 3·65 per cent. of nickel, in the normalised condition had a tensile strength of 44 tons with an elongation of 28 per cent., whilst in the notched bar tests it required 36 ft. lb. to fracture it. The same steel oil quenched, but untempered, had a tensile strength of 116 tons per sq. in., but the elongation fell to 10 per cent., and the energy absorbed in the notched bar test fell to 6 ft. lb. Another alloy steel containing ·38 per cent. of carbon, 1·72 per cent. of nickel, and 1·65 per cent. of chromium showed remarkable properties. In the normalised condition, the tensile strength was 100 tons per sq. in., the elongation 12 per cent., and the energy absorbed in the notched bar test was 5 ft.-lb. When oil quenched the tensile strength rose to 130 tons per sq. in., but the elongation was nil, and the notched bar test showed that 4 ft. lb. sufficed to break the specimen. By subsequent tempering, this figure was raised to 39 ft. lb. and the elongation to 20 per cent., but the tensile strength fell to 65 tons per sq. in. The report includes also heating and cooling curves for all the steels examined.

LITERATURE.

Topographic Maps and Sketch Mapping. By J. K. Finch, C.E., A.M., Associate Professor of Civil Engineering, Columbia University, New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 13*s.* 6*d.* net.]

Military training and the conditions of actual warfare have ever proved a great encouragement to the practice of map-making, and the last Great War, penetrating into so many lands, has compelled many, who had little previous experience, to make maps and to interpret the information that others had prepared from measurement and observation. The result has been to encourage the desire to take part in map delineation, and the author of the treatise facilitates the study by systematising the necessary instruction and precepts. The recreation of motoring and of camping-out has given to the subject a wide interest and more intelligent appreciation of the use of maps, and there should be no lack of pupils who would gain some entertainment as well as information, if they followed the instructions seriously and methodically. In earlier times, the circulation of maps was jealously withheld from public use and the information on which they were prepared was regarded by the Government as military secrets to be rigorously preserved, but in Napoleon's campaigns maps became a necessity of the first order, and were multiplied to such an extent that secrecy was no longer possible. The topographical surveys executed by the French engineers may have been wanting in accuracy and uniformity, but they fulfilled a purpose. Maps of Savoy, Northern Italy, and parts of Germany were constructed, and though Napoleon's stay in Egypt was short he produced a survey of 50 sheets of that country, but the unique formation of the Nile Valley would greatly facilitate the production. Surveys accurately executed require an enormous expenditure of both time and money, and the latter is hard to procure until the necessity for outlay is patent to the smallest intelligence. Many countries, long settled and in a high state of development, are still without any organised system of survey or reliable maps, and in this country, though the British Ordnance Survey has been carried on, more or less energetically since 1745, it was not till 1801, when the impetus of the Napoleonic struggle and the example set by France in making the *Carte de l'etat Major* had had their effect, that maps of desirable accuracy were published. After a century of continuous work this Survey may be

said to be completed, but a thorough revision is badly needed and is in active prosecution.

Only in the United States has the production of maps been accelerated by other than military exigencies. Economic progress and the rapid development of the country have demanded the study of its geological features and resources. Engineering projects and road-making need the knowledge of level variation, and the exhibition of contours. Such maps may not be well adapted for military purposes, but they show clearly the relief needed for many engineering works, a feature long neglected in map production, and even now too little valued. To many people one map is as good as another. They do not pause to consider upon what data it is based, or what degree of accuracy it may possess. In consequence of this indifference the author hints, and he is justified in so doing, that many who consider themselves highly educated are quite incapable of interpreting the symbols with which the map is covered.

To remedy this undesirable condition the author, who divides his book into three sections—Map Reading, Sketch-mapping, and Landscape Sketching—devotes considerable space to describing the conventional signs employed. These details may seem very elementary to the initiated, but the author is well advised, both on grounds of completeness and as an indication of the class he is addressing, to enter fully into these particulars. To determine the approximate distance between the two stations by means of the scale provided, usually exhausts the capacity and the ingenuity of the man in the street. The indications of relief and the methods adopted to exhibit the variations in the level of the Earth's surface require more study, and few are able to visualise the relief from a contour map, however ingeniously the information is conveyed. An unmeaning mass of curved lines fails to convey any distinct mental picture of the conformation of the ground, and the result of an attempt to disentangle what has the appearance of rather elaborate decoration usually ends in failure. The maps given to illustrate the method of delineation are rather too small and crowded to be of any real assistance. Interpretation of symbols is not made easier by the adoption of various devices in different countries, and the travelling motorist needs information as well as patience to determine the best route. Experience and instruction are both necessary in order to develop the ability to visualise the country represented by a map, the author can only apply the latter, but his methods are fully detailed and carefully arranged.

The problem of direction is easier, as the possibility of error is less, and of the several methods of indicating direction, it is satisfactory to note that the plan of fixing azimuths by dividing the horizon into degrees from 0 deg. to 360 deg. is favourably commented upon. This practice is rapidly displacing that of reckoning by compass-points, and since it has been adopted in describing the position of a vessel at sea, from the data furnished by wireless signals, the method is likely to come into general use. The construction of sections and profiles by means of the slope scale presents some slight difficulties, but none that is not easily removed by use and increased familiarity with the methods employed. It is a quite simple problem to determine the visibility of areas from a contour map, or to construct a landscape sketch from the same data, though few attempt to gain such assistance from the plane surface of a map. Such sketches are of the greatest use in identifying the local features of a country, but to the unaccustomed the task of producing the roughest sketch is irksome.

From interpreting the symbols and profiting by the experience of others to the construction of a sketch map that shall represent with some precision the surrounding country is an easy step. The rules prescribed in topographic surveying, or geodetic measurement, cannot be ignored, though the accuracy obtainable by appropriate instruments is excluded. Pacing has to take the place of the surveying chain, and the measurement of angles has to be accomplished without a theodolite. Employing only the simplest means, it is interesting to see how far a rigorously-closed traverse can be achieved, or what is the amount of the error of closure. The author suggests that 1 per cent. in a paced distance is an average error, but if this estimate is the result of experience in rough unmapped country, we should imagine there had been some compensation of errors, and that intermediate distances might show larger discrepancies. But the utmost that is produced by this method is a road map, showing direction and windings, but devoid of all details. These must be inserted by estimation, assisted it may be by the measurement of offsets. To indicate the variations of level or the irregularities of surface is more difficult and the insertion of correct contour lines taxes the skill and ability of the experienced map worker. One of the most important points is to analyse the relief visible from any set-up, and to decide upon a suitable scheme of controlling, or the selection of critical points in order to obtain the necessary data for the actual work of interpolating and sketching in the contours themselves. But the education is admirable and the process is one that should be practised in schools, where it might do something to displace or to supplement the featureless atlasses and wall maps that do duty for more modern appliances. The production of a map by the pupils is too often a lesson in freehand drawing and colouring, rather than an attempt to reproduce or to indicate the surface features. The ordinary wall map is a meaningless picture unless a significance is given to it by practice in the building up of local places and maps. If every map drawn served the definite purpose of distinguishing some particular part from a complex whole, the work of teaching geography, using the word in a wide sense, would be made more rational and attractive.

The third section is devoted to the subject of panoramic sketching, an art that finds its application mainly in military operations. Such sketches are useful to show the enemy positions, drawn to scale, with approximate ranges and descriptions of important targets. The object is to produce a conventional perspective drawing, with additional data giving the possible positions of enemy activity. We will hope, therefore, that the demand for this particular form of production will grow less, more especially as the result is apt to be neither artistic nor accurate. Here we think the author might have referred with advantage to the services rendered to topographical science by photography, since rapidity of production is essential to success. But at no stage of this process of map delineation is the assistance of the photographer enlisted. The capacity of producing a crude outline drawing is one that is well worth cultivating, but it is also wise to use any mechanical assistance.

If the artillery officer of the future will have little use for such panoramic sketches, it is different with the explorer. When much of the world's surface was unknown, we welcomed any authentic information that covered the disfiguring blank, even though the pioneer, who collected the details was not fitted for the task by special training. But now that the limits of the unknown are much curtailed, it is desirable that explorers should have regular training, adapted to the conduct of the work on strictly scientific lines. Mr. Finch's book and methods provide such training, and he hopefully contemplates the introduction of adequate schemes of instruction into regular college work. We trust he may be successful, for as a recreation, the practice is healthful and pleasant, and as a course of study edifying and useful. We must recognise that the action and reaction constantly at work between man and his topographical environment exercise no unimportant influence on his social and industrial development.

Ships' Boats; their Qualities, Construction, Equipment and Launching Appliances. By Ernest W. Blocksidge, M.I.N.A., M.Soc.N.A. and M.E. Longmans, Green and Co., 36, Paternoster-row, London. [Price, 25s. net.]

The subject of the life-saving appliances available on board ships is one which above all others achieves a periodical prominence in the public eye and in the popular press and which gives rise to a good deal of loose thinking and writing. The popular outcry for more and better life-saving equipment is the natural sequel to the calamities which are inevitably associated with navigation of the high seas and has no doubt had a considerable influence in the promotion of legislation dealing with this most important subject. Unfortunately the public knowledge of the appliances in use and the conditions under which they are mostly used is extremely vague, and as a consequence a great deal of misconception exists as to the extent and efficiency of life-saving facilities as at present fitted and as used under wreck or storm conditions. Consideration of the subject was stimulated by the investigations which followed the loss of the Titanic and the official recommendations of the various committees appointed to consider the subject were supplemented by a vast number of suggestions from members of the general public. Most of these suggestions were of no practical use whatever and showed an absolute lack of knowledge of the problem to be faced, but at least they showed the widespread interest which was taken in the subject. Of all the life-saving appliances fitted on board ship the best known and most important is undoubtedly the lifeboat, and the main efforts to increase the efficiency of life-saving appliances have had as their objects improvement in the construction and handling of boats.

Recent legislation has increased the number of boats which must be carried to such an extent that the stowage of the required number if of ordinary construction, becomes a matter of very grave difficulty, and in the case of some passenger steamers it is found to be impossible to find stowage for the required number of boats of ordinary construction. To meet this case a number of types of collapsible boats have been designed and these are now in very common use. To the qualities, construction and equipment of boats of normal construction and of the various types of collapsible boat, Mr. Blocksidge has devoted the largest part of his book, and the result is a most comprehensive treatise on these most important branches of the subject. The seaworthy qualities under the headings of stability and strength, as also the important element of capacity for carrying passengers are for any given size of boat largely dominated by the form of the boat and the importance of correct proportions in producing the best form of boat has been adequately dealt with by the Author. As in so many other branches of the shipbuilding industry an excellent case can be made out for the adoption of standard dimensions for all classes of ships' lifeboats, and the table of suggested standard dimensions covers all the ordinary requirements of present-day practice, while its universal adoption would be of the greatest possible benefit to the boat-building industry and would make for quicker deliveries to shipbuilders.

The construction of boats naturally involves consideration of the materials used as well as the methods of putting these together, and the selection and treatment of timber form a most important part of the business of boatbuilding. Steel lifeboats have never been adopted to the extent that their many good points would seem to warrant, and it is certainly a fact that such defects as are usually urged against them are largely the outcome of neglect on the part of those responsible for their upkeep. Of these defects corrosion is the most common, and it is one which careful periodical inspection and painting can do much to minimise. Steel lifeboats, on the other hand, have a very definite advantage over wood, in that they are not affected by the extremes of temperature met with in some voyages and which, in the case of wood lifeboats carried through the tropics have not infrequently made them quite unseaworthy. There are also cases on record of steel boats sustaining heavy blows and considerable indentations without loss of water-tightness. With the materials of construction of wooden boats, the author has dealt at considerable length, and his remarks on the qualities of the various kinds of timber used are obviously those of an expert.

The operations involved in the building of all types of boats are described in minute detail and reveal the author as not only an expert in his subject, but an enthusiast in promoting the higher development of the industry. With his remark that "piecework is a bugbear to honest workmanship" we cannot, however, agree, for given a fair

piecework price and efficient supervision, we see no reason to apprehend bad workmanship.

However satisfactory lifeboats may be from the constructional point of view, their efficiency as life-saving appliances depend, in very large measure, upon the certainty with which they can be rapidly transferred from their position on board ship to the water. With a vessel lying steady and upright on a calm sea this operation presents little difficulty, but such conditions rarely accompany the necessity for launching lifeboats, and, consequently, the means by which they can be transferred to the water assume a very special importance. In many cases it has been found that owing to a list which the ship may take consequent upon damage sustained, it is possible to launch only those on the lower side of the ship, and, with boats stowed under the older types of davits this fact at once reduces the number of boats which it is possible to launch, and therefore of the persons it is possible to carry, by half. With a view to meeting this case and others which may arise, much thought has lately been given to davits and lowering-gear generally, and, as a consequence, many ingenious devices have been evolved for dealing with the problem. Patent davits and blocks have multiplied rapidly during the last few years, and the shipowner has now a wide choice of appliances from which to select. The general trend of development has been in the direction of making one set of davits deal with more than one boat, either by stowing two or more boats within the reach of the davits, or by means of a system of transport which enables boats to be brought within the reach of the davits. A combination of "nested" lifeboats—that is, boats stowed two or three in the height and one inside the other, with one or other of the long reach types of davit—provides a means of rapidly and efficiently controlling the launching of a considerable number of lifeboats and is now being adopted by some important lines of passenger steamships.

A practical difficulty associated with the use of one set of davits for the lowering of more than one boat was met with in the liability of the manila falls to twist and the lower block to topple over when overhauling the falls for lowering the second boat. Most of the modern lowering systems seek to overcome this difficulty by adopting steel wire rope or chain instead of manila falls and by fitting a special non-toppling type of lower block, or by fitting a special device for preventing the blocks from toppling over. The author probably has considerable personal knowledge of the working of many of the patented types of davit now on the market, but he refrains from any expression of opinion as to the relative merits of each and contents himself with descriptions and illustrations of the more prominent types.

The construction and equipment of motor and surf boats and life rafts, details of construction of boat chocks and disengaging gear are among the other branches of the subject dealt with. The illustrations are numerous and excellent, and will be found of great assistance in clearly defining different methods of construction, while the Board of Trade regulations and the large number of scantling and other useful tables included in the book add considerably to its value as a book of reference both for the student and professional boatbuilder. As a textbook on the construction, equipment, use and maintenance of ships' boats and life-saving appliances generally, the volume reaches a very high degree of excellence, and in its strong advocacy of the best in life saving appliances is worthy of its dedication to the Seamen of the Merchant Marine.

BOOKS RECEIVED.

United States Coast and Geodetic Survey. Terrestrial Magnetism. Results of Magnetic Observations made by the United States Coast and Geodetic Survey in 1919. By Daniel L. Hazard. Washington: Government Printing Office. [Price 5 cents.]

Ein Neues Prinzip für Dampf-und-Gasturbinen. By Professor Konrad Baetz. Leipsig: Von Otto Spamer. [Price 16·5 marks.]

Report of the Committee of the Privy Council for Scientific and Industrial Research for the Year 1919–20. London: H.M. Majesty's Stationery Office. [Price 1*s.* net.]

The Manufacture of Sugar from the Cane and Beet. By T. R. P. Heriot, F.I.C. London: Longmans, Green and Co. [Price 24*s.* net.]

Super-Tax Tables. By G. O. Parsons, F.C.I.S. London: Sir Isaac Pitman and Sons, Limited. [Price 1*s.* net.]

Higher Mechanics. By Horace Lamb, D.Sc., LL.D., F.R.S. Cambridge: The University Press. [Price 25*s.* net.]

Tramway Motorman's Handbook: A Practical Treatise for Electric Tramcar Motormen and Conductors. Explaining the General Principles of the Construction and Operation of the Apparatus with which they are Directly or Indirectly Connected. By W. S. Ibbotson, B.Sc., A.M.I.E.E. London: E. and F. N. Spon, Limited. [Price 6*s.* 6*d.* net.]

Memoirs of the Geological Survey. Special Reports on the Mineral Resources of Great Britain. Vol. XVI *Refractory Materials: Ganister and Silica-Rock, Sand for Open-Hearth Steel Furnaces, Dolomite, Petrography and Chemistry.* By Herbert H. Thomas, M.A., D.Sc., A. F. Hallimond, M.A., and Ernest G. Radley. London: H.M. Stationery Office. [Price 5*s.* net.]

From Newton to Einstein, Changing Conceptions of the Universe. By Benjamin Harrow, Ph.D. London: Constable and Co., Limited. [Price 2*s.* 6*d.* net.]

The Journal of the Iron and Steel Institute. Vol. CI. Edited by George C. Lloyd, Secretary. London: Published by the Institute and by E. and F. N. Spon, Limited; New York: Spon and Chamberlain.

Industrial Electric Vehicles and Trucks. By W. Worby Beaumont, M.Inst.C.E., M.I.Mech.E., M.I.E.E. London: Charles Griffin and Co., Limited. [Price 15*s.* net.]

EXHIBITS AT THE MOTOR CAR SHOW.

Elsewhere in this issue (see page 644) we have commented upon the leading features of the Motor Car Show held during the past week at Olympia and at the White City, Shepherd's Bush. It is quite impossible to deal in detail with all the cars at so large an exhibition, and we are therefore compelled to limit ourselves to giving notes on some of them only. We commence these below, and hope to continue them in a subsequent issue. The limits of our space make it necessary to confine ourselves practically to machines embodying radical changes of design, or to types new to this market, but the omission to mention any particular make must, of course, not be taken to imply that the excellence of design and construction of many of our leading cars, are not appreciated.

The Twelve-Cylinder Packhard Car.

The Packhard car, shown by Messrs. W. C. Gaunt and Co., 198, Piccadilly, London, W. 1, is an interesting example of one of the highest class of American cars. It is also interesting as it has no less than 12 cylinders. These are arranged in two rows of six, and are placed at an angle of 30 deg. to the vertical, *i.e.*, 60 deg. to each other. Whether the 12-cylinder engine will come into general use it is impossible to say, but it has distinct advantages. The turning moment is necessarily more even than the six or eight-cylinder, and it is shorter than the six-cylinder in line or the eight in line. As compared with the eight-cylinder diagonal it is more perfectly balanced and narrower across the tops of the cylinders.

The bore and stroke of the cylinders is 3 in. by 5 in. (approximately 76 mm. by 127 mm.), and each row of six is cast *en bloc*. The cylinders have L heads, with the valves parallel to the cylinders and between the two rows. Each block of cylinders has a detachable head. A Bijur dynamo and self starter are fitted, and are exceptionally neat and compact. Ignition is by coil and two Delco distributors placed horizontally at the sides of a vertical shaft in the front of the engine where they are very accessible. At the top of this shaft is the contact breaker for a special plug used in connection with the carburettor. Lubrication is forced throughout. Water circulation is by two centrifugal pumps cast in one block, each supplying one set of cylinders. Petrol feed is by pressure, an air pump being placed on the engine. A multiple dry plate clutch transmits the power to a three-speed gear-box which is bolted up to the engine in the usual way. The whole is carried on three-point suspension. Semi-elliptic springs are used both back and front, the former being exceptionally wide and long. The springs act as radius rods, but the torque is taken by a pressed steel torque rod. A special feature is the arrangement for heating the mixture when cold. A small amount of mixture is drawn from a special attachment on the carburettor through a chamber which has a sparking plug in it. The mixture burns in this chamber, and the hot gases are drawn into the inlet pipe, thus heating the mixture. The whole design of this car is well worth studying, as in spite of the number of cylinders it is compact and simple in general arrangement and detail.

The A.C. Car.

A good example of modern English practice in the light car class is the "A.C.," shown by Messrs. Auto-Carriers, Limited, Ferry Works, Thames Ditton, Surrey. This car has a very small six-cylinder engine, the cylinders being 59 mm. by 100 mm. (approximately 2⅓ in. by 4 in.). In some ways this engine follows aero practice, for the cylinders are cast in one piece with the crank-case, and have steel liners. The cylinder heads are detachable, of cast-iron, and have overhead valves driven by an overhead camshaft. This shaft is driven through a vertical shaft and spiral gear placed at the after end of the engine. It drives the water pump and has a pulley for the dynamo drive. The crankshaft is provided with four main bearings, and has balance weights stamped on it. Lubrication is forced to all parts including the rockers of the valve gear.

The springs are quarter-elliptical for both front and back axle. The front springs have two leaves extending over the axle, but the upper of these is narrowed so that although two leaves take the weight here, only the bottom one is rigidly clamped to the axle and the upper one is free to slide on it.

The back axle is peculiar as the gear-box is carried on it, and the whole of the axle casing and torque tube is made of aluminium castings. The arrangement is extremely simple, as one casting forms the axle casing and carries the spring seats and back wheels, while a second casting bolted to the top of the first forms the gear-box and carries the worm, worm wheel and differential. This upper casting is extended forward and forms a torque tube. While in theory the use of aluminium for an axle casing appears bold it seems to have proved quite successful in practice. The whole design is excellent from the manufacturing point of view.

The Dort Car.

The Dort car, shown by Messrs. Whiting, Limited, 334, Euston-road, London, N.W., is an interesting example of American practice. This car is fitted with a four-cylinder engine having cylinders 3½ in. by 5 in. (approximately 89 mm. by 127 mm.) and has a two-bearing crankshaft. This naturally makes a very compact engine, the cylinder block only measuring 20½ in. overall, or less than many engines with cylinders ½ in. smaller in diameter. The cylinders are cast *en bloc*, and have a water space right round the barrels. The valves are all on one side, and a special feature of the exhaust manifold is that the passage for Nos. 1 and 4 cylinders is separate from that for Nos. 2 and 3. Magneto ignition is used, the magneto being very high up, and therefore accessible; lubrication is by trough. Water circulation is by thermo-syphon in place of by pump as usual in American practice.

A cone clutch transmits power to a three-speed gear-box carried on the back of the engine, as usual in American cars, with central change-speed lever. The final drive is by straight bevel, contrary to usual American practice, which is spiral bevel. A torque tube is used to control the axle, but this is not anchored by a ball joint at the front end, as usual, but has a fork going round the universal joint mounted so as to be capable of slight longitudinal motion. The back springs are cantilever and form the radius rods. Electric light and self-starter are, of course, provided, the dynamo being gear-driven. The engine and gear-box unit is mounted on the usual three-point suspension.

The Essex Car.

An American car which has put up some excellent performances in competitions is the Essex, shown by Essex Motors, Detroit, U.S.A. This car has a four-cylinder engine, 3½ in. diameter by 5 in. stroke (86 mm. by 127 mm. approximately), which has the inlets overhead, over the centre of the cylinders, driven by rocking levers and exhaust valves direct-driven at the sides, the crankshaft having three bearings. The generator for the electric light and self-starter is gear-driven, and ignition is by coil and distributor. Thermosyphon water circulation is used, contrary to usual American practice, and lubrication is by constant level splash.

A multi-disc clutch, with cork inserts, drives a three-speed gear-box having the change-speed lever mounted in the centre, the engine and gear-box forming one unit. The frame of this car is very simple, having nearly straight side members, wider apart at the back than the front. The back axle is of the usual bevel-drive pattern, both drive and torque being taken by the springs. The whole looks a very good example of modern American car practice, and recent performances appear to indicate that both design and workmanship are good.

The Berliet Car.

The Berliet car, exhibited by Messrs. L. C. Rawlence, Limited, 40 Sackville-street, London, W. 1, is a very interesting instance of an old-established French firm redesigning their cars to bring them into line with modern ideas.

The engine has four cylinders, 90 mm. by 130 mm. (3½ in. by 5⅛ in. approximately), and the cylinders are cast *en bloc* in one with the top half of crank-case; they have detachable heads. The valves are all on one side and the engine is very compact, measuring less than 21 in. over the cylinder casting. Lubrication is by trough and ignition by magneto. The car is fitted with a dynamo for the electric light and the self-starter is gear driven. A cone clutch transmits power

ENGINE OF THE FOUR-CYLINDER SEABROOK MOTOR CAR.

CONSTRUCTED BY MESSRS. SEABROOK BROTHERS, ENGINEERS, LONDON.

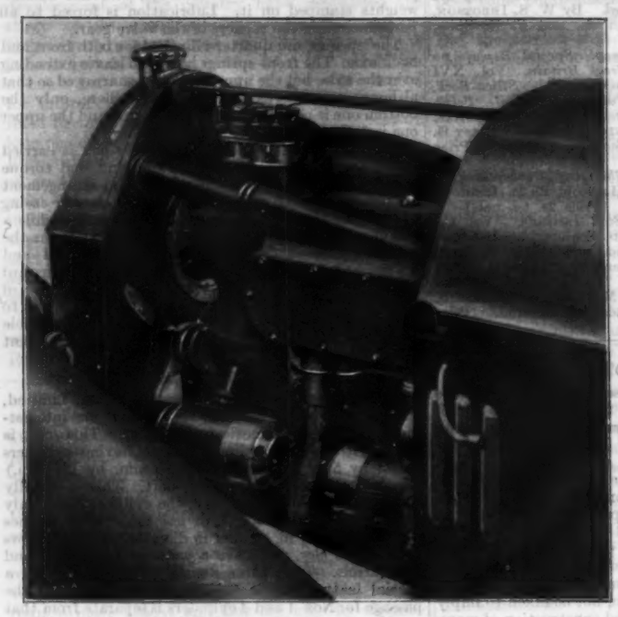


Fig. 1.

Fig. 2.

to a three-speed gear-box, which is made in one unit with the engine and has the change-speed lever in the centre.

The back axle is driven by spiral bevel gear, and is controlled by a torque tube which is anchored by a ball joint at the back of the gear box. Both brakes are on the back hubs. The frame is of simple construction, having nearly straight side members, wide apart at the back and narrow in front. There are only three cross-pieces. The engine and gear-box are mounted on a three-point suspension.

This chassis looks simple and substantial and, having few parts, is probably relatively light. It appears to be an excellent example of modern design as made by this well-known firm of old standing.

The Seabrook Car.

A car with several novel features is the Seabrook, shown by Messrs. Seabrook Brothers, 57, Great Eastern-street, London, E.C. 2. The engine, shown in Figs. 1 and 2 above, has four cylinders, 69 mm. by 120 mm. (approximately 2¾ in. by 4¾ in.) which are cast in one piece with the top half of the crank-case, cast-iron liners being used for the cylinder barrels. The valves are in the cylinder head, which is detachable. The head is of aluminium, with aluminium bronze valve seats cast in. An overhead camshaft is used, driven by a vertical shaft at the front of the engine. The magneto is mounted so that its spindle is vertical at the top of this shaft. The contact-breaker and distributor are thus very accessible, which is a great advantage. This position appears to be good where the camshaft is driven by a vertical shaft. Forced lubrication to main bearings and camshaft is provided, and water circulation is by thermosyphon. An inverted cone clutch transmits power to a four-speed gear box which is bolted to the engine to form one unit. The frame is simple, consisting of two nearly straight side members, wider apart at the back than the front with two pressed steel and two tubular cross-members. Cantilever springs are used for the back axle, the movement of which is controlled by a short torque tube which is pivoted on the same centre as the springs. The back axle is bevel driven, but has no differential gear. As a result of this, it is possible to place the foot brake drum on one wheel and the hand brake drum on the other, thus very much simplifying the brake gear and connections.

The Co-Tay Car.

A light two-seated car, with several novel features is the Co-Tay, shown by Bramco, Limited, 2, Radford Fields, St. Nicholas-street, Coventry. This vehicle is of American design and is fitted with a vertical four-cylinder "Cameron" engine, having four cylinders, 2¾ in. by 4 in. The valve gear on this engine is peculiar. The valves are horizontal, the inlets being on one side and the exhausts on the other. Two vertical shafts are provided on each side of the engine, each carrying a T-head at the top. A camshaft is provided below the crankshaft, and each vertical shaft has an arm with a roller running in a groove in the camshaft. The vertical shaft is thus rocked on its centre, and the T-heads each operate one pair of valves. A fan is provided to blow a current of air into the cylinders.

Transmission is by multiplate clutch to a three-speed gear-box of ordinary design and a bevel-geared back axle.

The frame is of wood, and is really part of the body, which is entirely of three-ply wood. The wheels are also of five-ply wood and have 30-in. by 3½-in. tyres. Electric light and self-starter are provided. The weight of the machine is about 700 lb., *e.g.*, 6¼ cwt.

The Sheffield Simplex Car.

Messrs. Sheffield Simplex, Limited, 20, Conduit Street, London, W., show a chassis which has several modifications of their previous practice. The engine has larger bore cylinder than previously, the bore and stroke now being 4½ in. × 5 in. (114 × 127 mm.) each cylinder being cast separately with the valves on the same side. The pistons are of the crosshead type, *i.e.*, the connecting rod is not fixed to the piston proper but to a crosshead running in a guide separate from the cylinder. The air for the carburettor is drawn past the valve springs and through the space between the crosshead and piston and the gas from the carburettor is taken through a passage cast round the cylinder barrels to the valve pockets. The camshaft has an index plate on it which can be seen through an inspection door showing the position of the pistons. A U.S.L. self starter is used, the armature forming the flywheel and having an eight armed field magnet inside it. This does away with all gearing. Two ignitions are provided, magneto and coil, with distribution. The gear box is at the front end of the torque tube and both brakes are in the back axle. Other features of construction are generally as in previous practice.

The Datum Line in Industry.—Messrs. Lambourne and Co., Limited, constructional engineers and contractors, Openshaw, Manchester, inform us that they have introduced at their works a scheme of payments by results, introducing the use of a datum line. The datum line was fixed at a conference between a committee of workmen and the management; it is the average output in tons for the six months preceding the conference. The previous method of payment was by individual piece-work rates; the new scheme is the outcome of the men's own request. The men have had access to Messrs. Lambourne's books for fixing the datum line. This is governed by the numbers employed and hours worked, and will serve for depressed as well as for busy periods. Since the scheme was adopted, output has risen above the datum line.

The Concrete Institute.—The Concrete Institute has issued a list of forthcoming meetings. These include one on the 25th inst., when the presidential address will be delivered by Mr. E. Fiander Etchells. Further meetings will take place on December 16, in January and the following months, for the reading and discussion of papers. Further information can be obtained from the Institute, Denison House, 296, Vauxhall Bridge-road, Westminster, S.W. 1.

A New Advance in Wireless Telegraphy.—At the inaugural address on "Wireless Telegraphy and Telephony," to be delivered on Wednesday, November 17, at 8 p.m., to the Royal Society of Arts, John-street, Adelphi, by Mr. Alan A. Campbell Swinton, F.R.S., chairman of the Council of the Society, there will be shown, it is hoped, amongst other things, the automatic printing in ordinary Roman type of wireless messages received in the lecture hall from a distance. This will be the first time that this new departure in wireless telegraphy has been exhibited. The automatic telegraphic printing apparatus that will be employed is the invention of Mr. F. G. Creed, of Croydon.

Shipbuilding in Canada.—There is observable in Canada a tendency for steel shipbuilding to concentrate in fewer hands, says *Iron and Steel of Canada*, and the closing down of several yards indicates that those yards which are most likely to survive as permanent enterprises are those associated with powerful allied interests, and situated advantageously with regard to delivery of steel products, engines and boilers, and close to a resident population of industrial workers. Following the closing down of the Dominion Shipbuilding Company's yard at Toronto, there is announced the permanent closing down of the British American Shipbuilding Company's plant at Welland, to take place after the launching of the Canadian Squatter. The number of men employed in this yard has been gradually diminished, and when work was at its busiest 570 men were employed. The Foundation Company's yards at Vancouver—which built wooden vessels—has been dismantled. At one time 4,000 men were employed by this company. The equipment has been disposed of in large part to the steel-shipbuilding companies in Vancouver and Victoria. The Harbor Marine Company, of Victoria, following the launching of the Canadian Traveller is laying off the greater part of its employees; following the completion of the Canadian Winner it is expected that shipbuilding at this Victoria yard will cease. The yards that will continue to build steel ships will include those associated with the British Empire Steel Corporation in Eastern Canada, Canadian Vickers of Montreal, the Prince Rupert Dry Dock and Engineering Company, the Coughlan and Wallace yards at Vancouver. That there would be some elimination of the shipyards, not possessing the necessary elements of permanence, following the passing of the urgent situation occasioned by the war, was expected by everyone acquainted with the competition that exists in steel shipbuilding, but it is hoped that the decline in the industry in Canada will not be allowed to proceed too far. No doubt the Canadian Government has a policy on this matter, and it has set out to create and perpetuate in Canada both a mercantile marine fleet and the means to enlarge it.

THE BUREAU OF ROLLING-MILL RESEARCH.*

By W. B. Skinkle.†

Professor Trinks has just given you a paper setting forth the present status of the rolling-mill as a scientific problem, laying stress on those points which still remain unsolved, and on which engineers are badly in need of more data obtained under conditions in which each of the many variables may be controlled with a far greater degree of accuracy than is at present possible.

The inability of engineers to exercise accurate control over these variables makes it advisable to install a special mill, designed for experimental work, and equipped with recording instruments which will enable the observers at all times to determine just what is taking place in all its parts during an experimental run. The requirements for such a mill might be classed under the following heads:—

1. Plenty of power.
2. Ability to reverse the direction of rotation at will.
3. A wide range of speeds.
4. A wide range of types of mills.
5. Ability to roll a wide range of products.
6. Ability to assemble a wide range in sizes of rolls.
7. A set of measuring instruments which will make possible the accurate determination of what is going on during the experiment.
8. Equipment so designed that alterations to suit special experiments may be easily made at a comparatively low cost. In general this might be summed up in the single word, "flexibility."

The Carnegie Institute of Technology will set aside building space of approximately 30 ft. by 135 ft., to house the mill and its auxiliary equipment.

Fig. 1 shows a diagram of this laboratory and the equipment which we contemplate installing. The mill and drive, as will be seen, consist of a motor, suitable gear reduction, three stands of pinion housings, three stands of mill and three lines of shoe-plate. The auxiliary equipment will consist of two stationary heating furnaces, one movable electric furnace, two hot saws and a roll lathe, with roll racks, steel racks, &c.

The source of power supply for driving the mill motor will be obtained from a 600-kw., 230-volt direct-current Westinghouse generator direct connected to a 30-in by 42-in. Mesta uniflow steam engine. This generator will be withdrawn from the general circuits at the Institute during the operation of the experimental mill and will be placed on the armature circuit of the mill motor. The fields of both the mill motor and the generator will be excited from the regular 230-volt supply. The generator is to be operated at all times as a shunt-type machine.

The motor will have both series and shunt field windings and will operate either as a compound or a shunt machine depending on the position of the controller in the pulpit. When ready for operation the generator

Fig. 1. DIAGRAM OF MILL AND DRIVE.

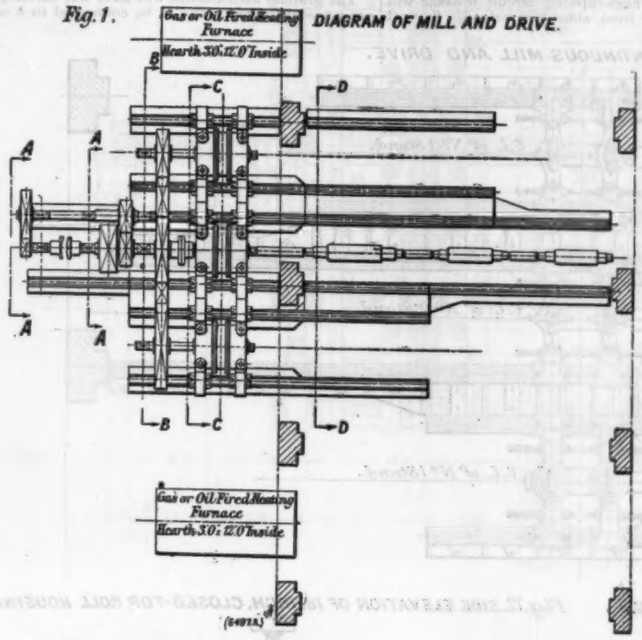


Fig. 2. TORQUE SPEED CURVE OF MILL MOTOR.

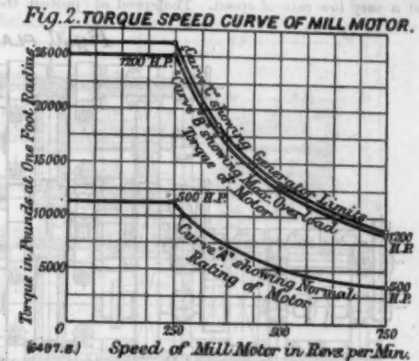


Fig. 3. GEAR DIAGRAM No 1.

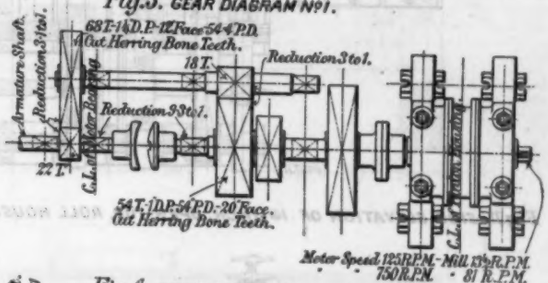

Armature Shaft.
Reduction 3 to 1.
C.L. of Motor Bearing
68 T-1½ D.P-12 Face-54 P.D. Cut Herring Bone Teeth.
18 T.
Reduction 3 to 1.
Reduction 3 to 1.
22 T.
C.L. of Motor Bearing
54 T-1 D.P-54 P.D.-20 Face. Cut Herring Bone Teeth.
C.L. of Pinion Bearing
Motor Speed 125 R.P.M.-Mill 13⅓ R.P.M.
750 R.P.M. - 81 R.P.M.

Fig. 4. GEAR DIAGRAM No 2.

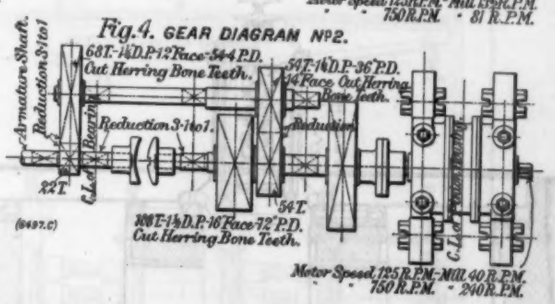

Armature Shaft.
Reduction 3 to 1
C.L. of Motor Bearing
68 T-1½ D.P-12 Face-54 P.D. Cut Herring Bone Teeth.
54 T-1½ D.P-36 P.D. 34 Face. Cut Herring Bone Teeth.
Reduction 3-1 to 1.
Reduction
22 T.
54 T.
108 T-1½ D.P-16 Face-72 P.D. Cut Herring Bone Teeth.
C.L. of Pinion Bearing
(6497.C)
Motor Speed 125 R.P.M.-Mill 40 R.P.M.
750 R.P.M. - 240 R.P.M.

Fig. 5. GEAR DIAGRAM No 3.

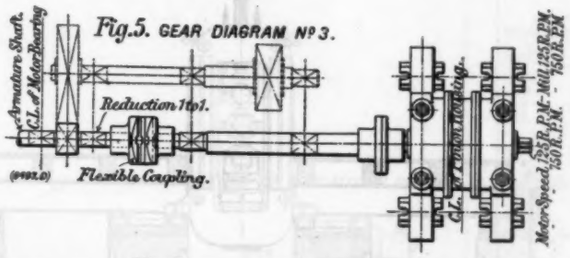


Fig. 6. SECTION THROUGH DRIVING SHAFTS, ON LINE A.A. OF Fig. 1.

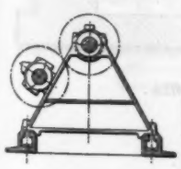


Fig. 7. ELEVATION OF BEARINGS FOR SPUR-GEAR DRIVE, ON LINE B.B. OF Fig. 1.

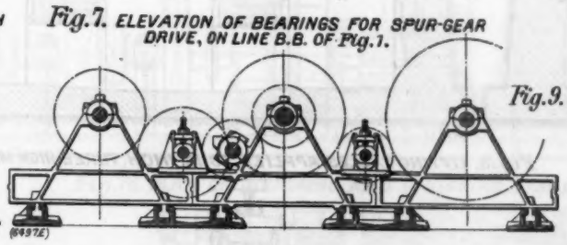


Fig. 8. SIDE ELEVATION OF PINION HOUSINGS, ON LINE C.C. OF Fig. 1.

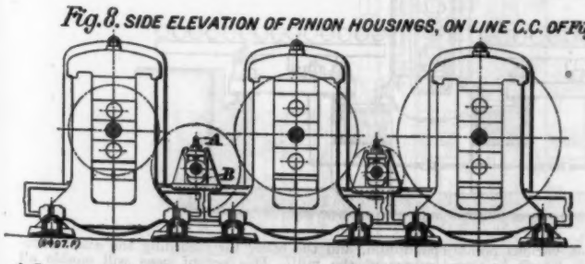
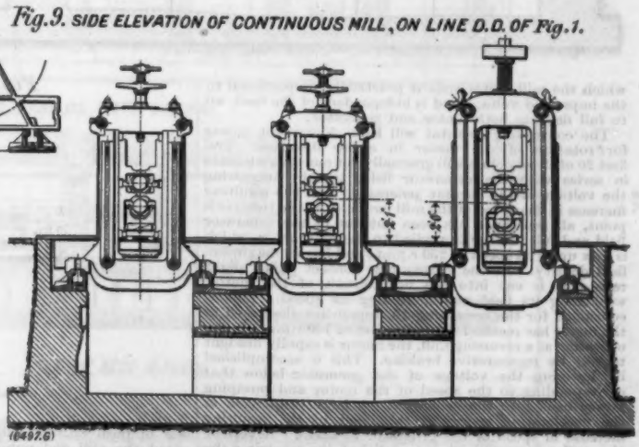


Fig. 9. SIDE ELEVATION OF CONTINUOUS MILL, ON LINE D.D. OF Fig. 1.



* Paper read before the Engineers' Society of Western Pennsylvania.

† Director, Bureau of Rolling-Mill Research, Carnegie Institute of Technology, Pittsburgh.

will be running at full speed, the rheostat handle in the pulpit will be in the "off" position, and the generator will have no field current and consequently will generate no power. The mill motor will therefore be stationary. At the first contact point the motor fields will receive the full 230-volt line voltage and have maximum density while the armature fields will receive only a very light current as the maximum resistance will be in this circuit. A current at very low voltage will therefore be sent to the mill motor, the armature of which will revolve in the strong field at a very low rate of speed. The speed at which the mill motor runs is practically proportional to the impressed voltage and is independent of the load, up to full field on both motor and generator.

The controlling rheostat will have 50 contact points for rotation of the motor in either direction. The first 20 of these points will gradually cut out the resistance in series with the generator field, thereby increasing the voltage of the current generated, with the resulting increase in the speed of the mill motor. At the twentieth point, all resistance has been cut out of the generator field and full voltage is applied to the mill motor, which is now up to its speed of 250 r.p.m., and has its maximum field density. At the twenty-first contact point, slight resistance is cut into the field circuit of the motor, weakening its field and increasing its speed. This is continued for the remaining 29 steps when the speed of the motor has reached the maximum of 750 r.p.m. When operating as a reversing mill, the motor is rapidly brought to rest by regenerative braking. This is accomplished by lowering the voltage of the generator below that corresponding to the speed of the motor and pumping power back into the generator. A large proportion of the decelerating energy is reclaimed by the resulting increase in speed of the generator flywheel. Reversing the mill motor will be accomplished by reversing the direction of the current in the generator field. This avoids the difficulty of handling and reversing the heavy currents in the armature circuit.

Fig. 2 shows the torque-speed curves of both motor and generator. Curve A is the normal continuous duty curve of the motor. Curve B is the maximum torque curve of the motor, and curve C is the maximum torque curve of the generator.

The motor will be specially designed for rolling-mill service, particular care being taken to insure reliability under the conditions to be met in the severe service of an experimental mill. As already mentioned, it will have a speed range from zero to 750 r.p.m. in either direction.

Special attention will be given to the windings of the armature, and to the commutator on account of the severe service due to the sudden large changes in speed, when reversing. The control will be accomplished by means of a hand-operated rheostat, and will be so interlocked that the motor will always have a full field when starting. Between the generator and the motor a manually-operated, high-capacity circuit breaker will protect the generator from abusive overload. Several sets of push buttons will be located at various points about the mill and pulpit, to trip this circuit breaker in case of emergency.

In addition to the hand-operated rheostat for controlling the motor, the pulpit will contain a switchboard on which will be mounted an indicating ammeter and voltmeter as well as the necessary signal lights to indicate the position of the main circuit breaker.

For observing the power conditions when the mill is operating, the following instruments will be used:—

One indicating, direct-current voltmeter (zero centre).
One indicating, direct-current ammeter (zero centre).
One indicating speed meter for the mill motor (zero centre).
One indicating speed meter for the generator (single deflection).
One graphic, direct-current voltmeter (zero centre).
One graphic, direct-current ammeter (zero centre).
One graphic speed meter for the motor (zero centre).
One graphic speed meter for the generator (single deflection).
One magneto, connected to the motor shaft.
One magneto, connected to the generator shaft.

The graphic instruments will have one chronographic pen on each margin—one to be connected to a seconds pendulum, and the other for recording the exact revolutions of the mill. This set of pens will enable all recording diagrams to be connected together when they are plotted on the final report charts.

The recording instruments will all be of the switchboard type. As it is the intention of the Bureau to run repeated tests it would be neither convenient nor good engineering to use portable test instruments for this work.

Figs. 3 to 5 show three possible assemblies of the gear reductions between motor and mill. In Fig. 3 the power is transmitted from the armature shaft through the motor pinion and gear to the jack shaft with a reduction of 3·1 to 1. From the jack shaft through its pinion

Fig. 10. PLAN OF CONTINUOUS MILL AND DRIVE.

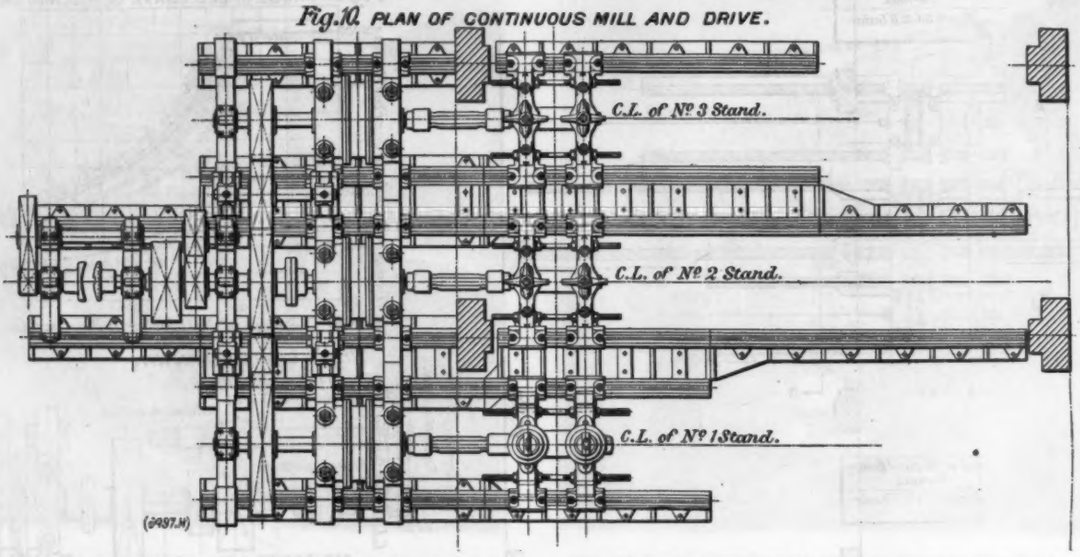


Fig. 11. SIDE ELEVATION OF 14-INCH, OPEN-TOP, ROLL HOUSING.

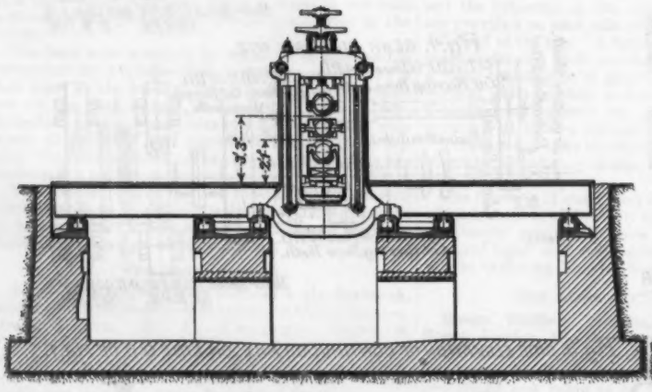


Fig. 12. SIDE ELEVATION OF 18-INCH, CLOSED-TOP, ROLL HOUSING.

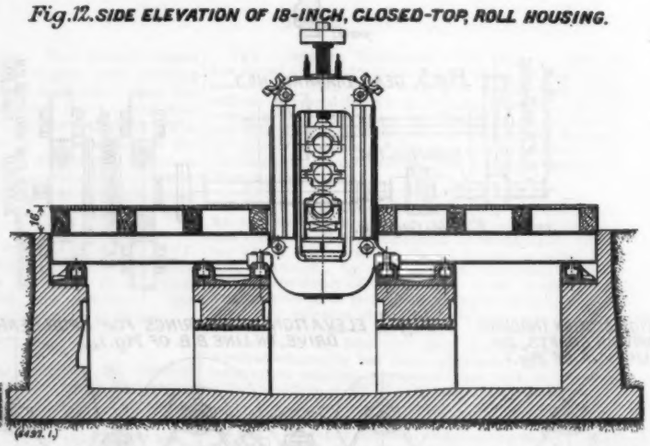
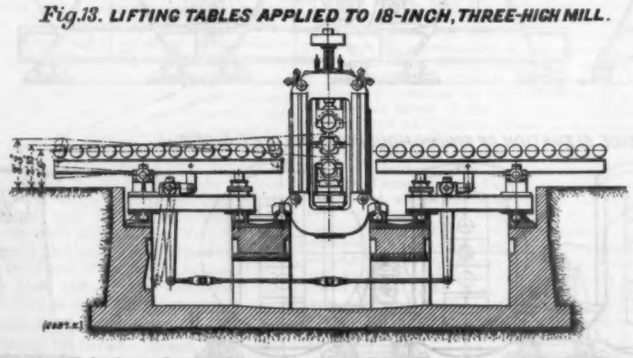
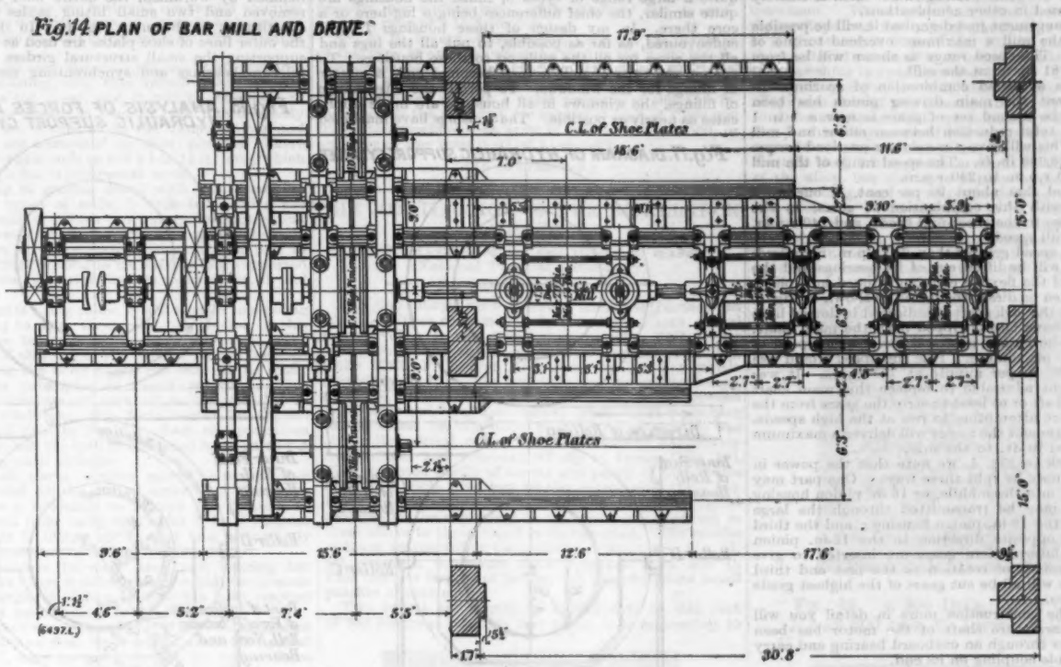


Fig. 13. LIFTING TABLES APPLIED TO 18-INCH, THREE-HIGH MILL.



THREE-HIGH HAND FED EXPERIMENTAL BAR MILL.

Fig. 14. PLAN OF BAR MILL AND DRIVE.



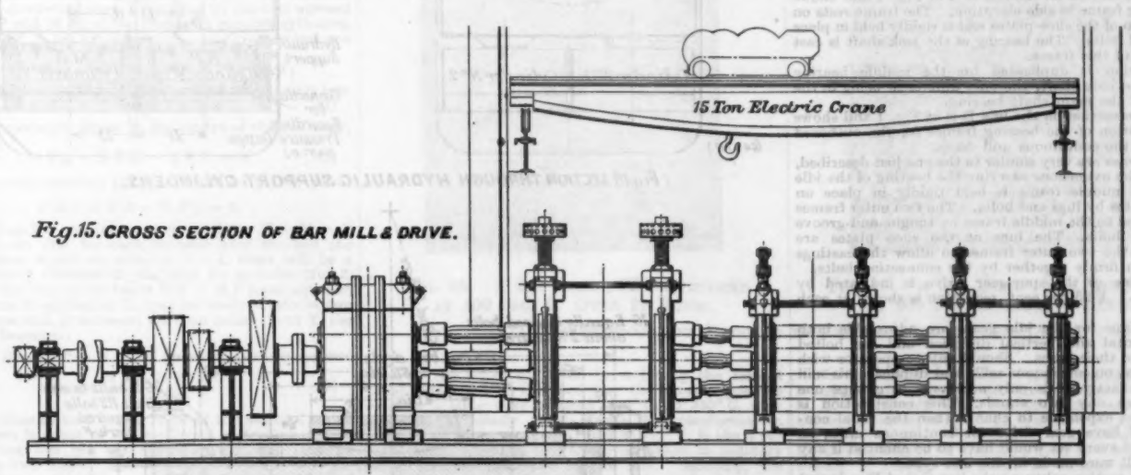
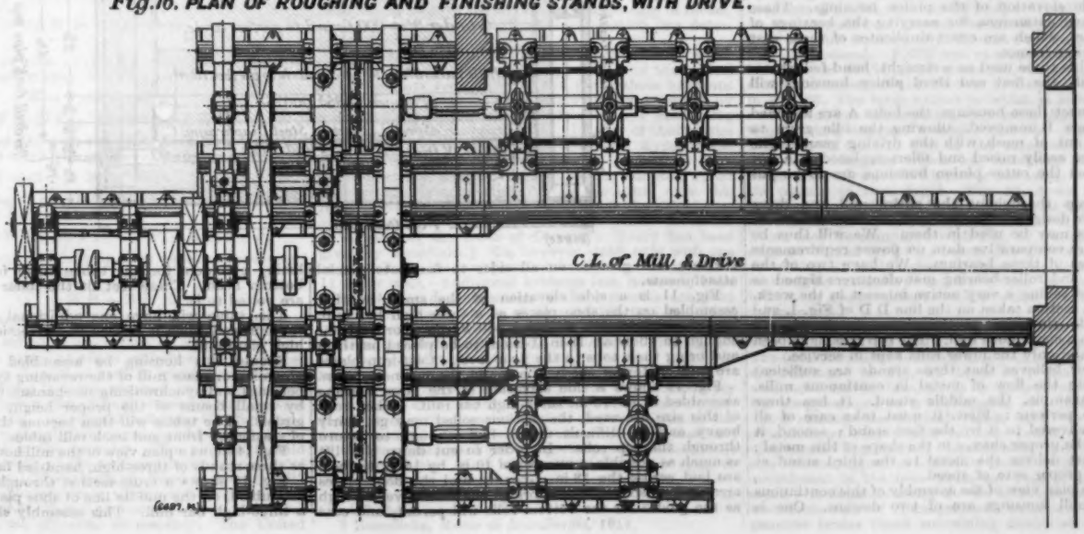


Fig. 15. CROSS SECTION OF BAR MILL & DRIVE.

Fig. 16. PLAN OF ROUGHING AND FINISHING STANDS, WITH DRIVE.



and the main driving gear to the main shaft we secure a second reduction of 3 to 1, making a total reduction of 9·3 to 1 between motor and mill. You will note a second gear on the main driving shaft which is entirely idle. This is used in other combinations.

With the arrangement just described it will be possible to deliver to the mill a maximum overload torque of 230,000 lb.-ft. The speed range as shown will be from 13·5 r.p.m. to 81 r.p.m. at the mill.

Fig. 4 shows a second combination of gearing. In this arrangement the main driving pinion has been changed, and the second set of gears is now a 1 to 1 ratio, giving a total reduction between motor and mill of 3·1 to 1. This will give a maximum overload torque at the mill of 78,000 lb.-ft. The speed range of the mill will be from 40 r.p.m. to 240 r.p.m.

It is expected that about 90 per cent. of our work will be done with this combination of gears, as the 40 r.p.m. is close to the sheet-mill speed, and 240 r.p.m. is a good bar-mill speed.

When a mill speed greater than 240 r.p.m. is desired, the jack shaft will be lifted out of its bearings and the missing parts of the flexible coupling slipped into place. The mill will then be direct-connected as shown in Fig. 5. In this drawing the jack shaft is indicated in dotted lines and the gears have been stripped from the main shaft. At 240 r.p.m. the largest gear will have a rim speed of nearly 5,000 ft. per minute. This rim speed would rise to nearly 15,000 ft. per minute at 750 r.p.m. It was therefore thought advisable to replace this main shaft with a second shaft or at least to strip the gears from the main shaft before attempting to run at the high speeds. With this arrangement the motor will deliver a maximum torque of 25,000 lb.-ft. to the mill.

Referring back to Fig. 1, we note that the power in the main shaft may be split three ways. One part may be sent directly into the middle, or 16-in. pinion housing a second part may be transmitted through the large driving gear to the 18-in. pinion housing; and the third portion in the opposite direction to the 12-in. pinion housing. The intermediate gears are inserted to give the correct direction of rotation to the first and third pinions. These will all be cut gears of the highest grade herringbone type.

Taking up the construction more in detail you will note that the armature shaft of the motor has been extended to pass through an outboard bearing and carry half of the flexible coupling on its end.

Fig. 6 is a section on the line A A of Fig. 1 and shows this bearing frame in side elevation. The frame rests on an extension of the shoe-plates and is rigidly held in place by lugs and bolts. The bearing of the jack shaft is cast to the side of this frame.

This section is duplicated for the middle bearing frame of the jack shaft, the only difference being in the diameter of the main shaft bearing.

Fig. 7 is a section on the line B B of Fig. 1 and shows a side elevation of the bearing frames for the outboard bearings of the continuous mill drive.

These frames are very similar to the one just described, except for the extensions carrying the bearing of the idle gears. The middle frame is held rigidly in place on the shoe plates by lugs and bolts. The two outer frames are connected to the middle frame by tongue-and-groove joints with bolts. The lugs at the shoe plates are omitted on the two outer frames to allow the castings to be drawn firmly together by the connecting bolts.

The outline of the spur-gear drive is indicated by dotted lines. A 25 per cent. reduction is shown at each pass.

The bearings for the idle gears are adjustable both in a horizontal and vertical direction and are bolted and keyed to their bases. Should any co-operator wish to experiment on continuous mills and duplicate his mill conditions exactly, it is only necessary to change one gear between any two stands. This construction is therefore less expensive to change than the usual construction of bevel-gear drive for continuous mills, as both gears of every set would have to be changed if any change at all were made in this last type.

Fig. 8 is a section taken on the line C C of Fig. 1, and shows a side elevation of the pinion housings. These housings have extensions for carrying the bearings of the idle gears, which are exact duplicates of those cast on the bearing frames.

If the mill is to be used as a straight, hand-fed, three-high bar mill, the first and third pinion housings will not be used.

To disconnect these housings, the bolts A are loosened and the fillers B removed, allowing the idle gears to drop down out of mesh with the driving gears. The gears may be easily raised and fillers replaced in a few minutes when the outer pinion housings are to be put into service.

All bearings throughout the entire mill and drive are to be so designed that babbitt, bronze, rollers, or ball bearings may be used in them. We will thus be able to secure comparative data on power requirements for all classes of these bearings. We have two of the leading ball and roller-bearing manufacturers signed as members and taking a very active interest in the work.

Fig. 9 is a section taken on the line D D of Fig. 1, and shows a side elevation of the three stands of mill assembled as a continuous mill. The top rolls have been abandoned and only the lower rolls kept in service.

The author believes that three stands are sufficient to investigate the flow of metal in continuous mills. Take, for example, the middle stand. It has three functions to perform: First, it must take care of all the metal delivered to it by the first stand; second, it must make the proper change in the shape of this metal; third, it must deliver the metal to the third stand at exactly the proper rate of speed.

Fig. 10 is a plan view of the assembly of this continuous mill. The mill housings are of two designs. One is a large closed-top housing and the other two are smaller open-top housings.

I would call your attention to the fact that, through quite a large range of types of mills, the housings are quite similar, the chief differences being a lug here or a core there. In my design of these housings I have endeavoured, as far as possible, to put all the lugs and all the cores for all the mills on to these housings. To change the type of mill it then becomes only a matter of fillings for the windows. To permit the interchange of fillings, the windows in all housings are made duplicates as nearly as possible. The housings have machined surfaces and grooves on all sides to facilitate special attachments.

Fig. 11 is a side elevation of the small housing assembled on the shoe plates as a three-high bar mill. The shoe plates are dropped below the floor just far enough to allow an 18-in. I-beam to be placed on them and bring their tops to the floor level. Cast-iron plates are laid on top of these I-beams in the manner shown.

Fig. 12 shows a side elevation of the large housing assembled as an 18-in. three-high bar mill. When rolls of this size are used, the sections rolled may get fairly heavy and be difficult to lift high enough to return through the top rolls. In order to cut down this lift as much as possible, a number of 10-in. by 16-in. timbers are laid across the 18-in. I-beams, and the floor plates arranged as shown. This brings the floor level as high as the guides for the bottom rolls will permit, and cuts down the lift necessary to return the billet through the top rolls.

In case the bloom to be rolled is too heavy to be handled by workmen, the entire floor system may be removed and two small lifting tables of light design substituted, as shown in Fig. 13. In this construction the outer lines of shoe plates are used as foundations for supporting the small structural girders that carry the fulcrum bearings and synchronising mechanism. The lifting cylinders for the tables have feet cast on the bottom head. These feet fit the inner shoe plate and are bolted to it.

This table will have one additional roller added to the mill end when it is used in connection with a three-high plate mill.

Should this housing be assembled as a two-high blooming or plate mill of the reversing type, the fulcrum bearings and synchronising mechanism may be replaced by small beams of the proper height laid across the girders. The tables will then become the ordinary type of stationary front and back mill tables.

Fig. 14 shows a plan view of the mill housings assembled as three stands of three-high, hand-fed bar mill.

Fig. 15 shows a cross-section through the mill when assembled, on the middle line of shoe plates, and used as a three-high bar mill. This assembly shows 16-in. mill

Fig. 17. DIAGRAM OF HYDRAULIC SUPPORT CYLINDER

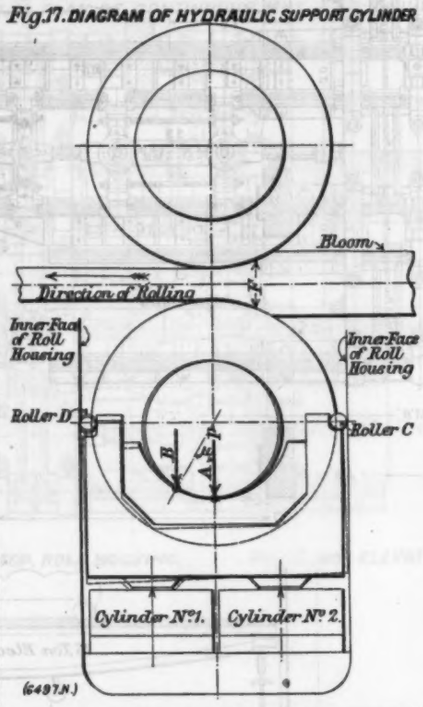


Fig. 18. ANALYSIS OF FORCES ACTING ON HYDRAULIC SUPPORT CYLINDERS.

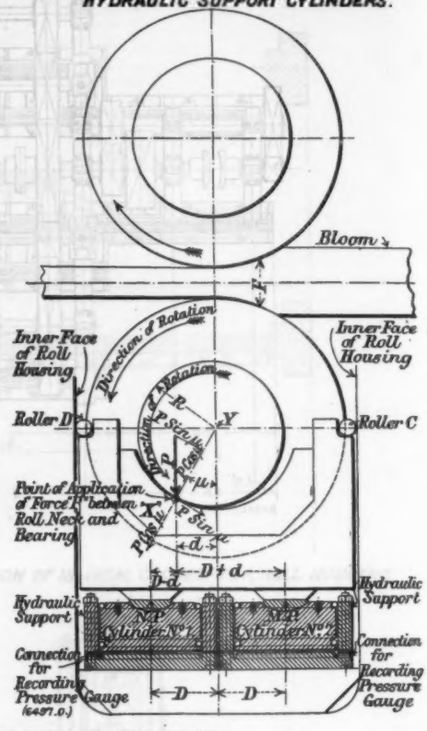
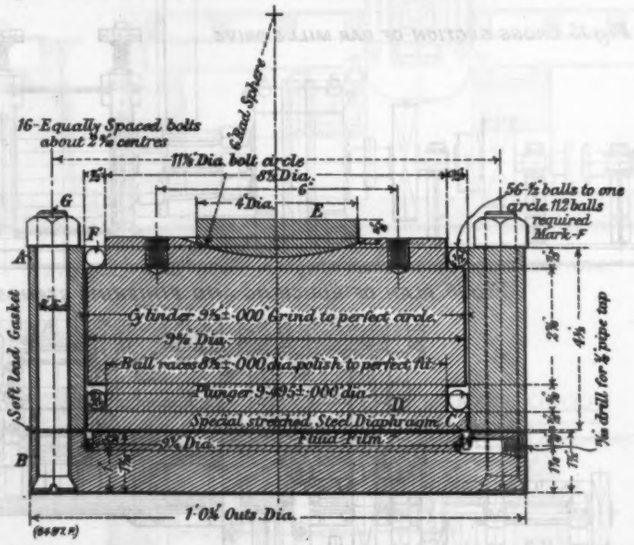


Fig. 19. SECTION THROUGH HYDRAULIC SUPPORT CYLINDERS.



pinions driving the first stand of 18-in., three-high mill and the second and third stands of 16-in. three-high mill. There is a slight lead on the spindles to and from the 18-in. stand. All pads on both roll necks and spindles are made of the vibrating type to permit as much of this lead as possible without interfering with the operation of the mill.

In extreme cases, say, for example, an 18-in. roughing and a 10-in. finishing mill, this spindle lead between stands would be too great, and it will be necessary to assemble them as shown in Fig. 16. In this assembly the 18-in. rolls are connected to the 18-in. pinions and the 10-in. rolls are connected to 12-in. pinions. There is room between the stands to roll a bar 12 ft. long, which should be enough for experimental work.

Before dealing in greater detail with the assemblies of the various types of mills, I wish to describe the devices by means of which we expect to locate and measure the various losses of power throughout the mill.

Fig. 17 shows an exaggerated diagram of a pair of rolls, the lower neck resting in its bearing and supported on two hydraulic support cylinders marked No. 1 and No. 2.

When a bloom is being rolled it will exert a separating force F, tending to open these rolls. A portion of this force F will be transmitted to each roll neck. The exact amount of this force will depend on the location of the pass along the body of the roll and can be easily figured by the principles of beam reactions. This force transmitted to one roll neck will be designated as P. Under static conditions, this force would be applied as shown by full lines in Fig. 17. Such an application would cause one-half the load as indicated by the arrow A to be carried by each cylinder.

When rotation starts, contact moves to some other point as indicated by the dotted arrow B. The lower roll carrier has a tendency to assume the position as shown by dotted lines using the roller C as a fulcrum point, the roller D lifting off its seat and giving only the very low resistance of rolling friction.

When the contact between neck and bearing has moved to a point where it slides back as rapidly as it tends to climb, the angle of sliding friction has been reached and the system again comes to equilibrium.

These conditions are analysed in Fig. 18. Examination of this figure shows that the vertical force P, applied at the point X, may be resolved into its normal force ($P \cos \mu$) and a tangential force ($P \sin \mu$). The diagram shows the downward force P, resisted by the two upward forces N P and M P, of the hydraulic support cylinders, where M and N are some fractions, one greater and one less than ½.

Taking moments about the point X, we have:

$$+ N P (D - d) - M P (D + d) = 0, \text{ which expands into}$$
$$N P D - N P d - M P D - M P d = 0. \quad (1)$$

Taking moments about Y, the centre of the roll neck, we have:

$$- P d + N P D - M P D = 0. \quad (2)$$

Subtracting equation (2) from equation (1) we have

$$P d - N P d - M P d = 0.$$

Cancelling P d and rearranging, we have $N + M = 1$. This shows that for each increase over one-half the load P, that is put on cylinder No. 1, there will be a corresponding decrease in the load on cylinder No. 2, and that the sum of the loads N P + M P must equal P.

The force P, applied at X, may be resolved into its two components and, if moments are then taken about Y, the equation becomes:

$$P \sin \mu R = (N P - M P) D, \text{ which will transpose into}$$
$$\sin \mu = \frac{(N P - M P) D}{(N P + M P) R}. \quad (3)$$

We have thus arrived at the value of the angle of which the tangent is equal to the coefficient of friction.

The work lost per revolution of the rolls may be figured in two ways. First:

Work lost = (normal pressure) (coefficient of friction) (distance moved).

In this case, letting W = work lost per revolution, we have:

$$W = (P \cos \mu) (\tan \mu) (2 \pi R). \text{ But } \cos \mu \tan \mu = \sin \mu.$$

The equation may therefore be written,

$$W = P \sin \mu \, 2 \pi R,$$
$$\text{or } W = (N P + M P) \sin \mu \, 2 \pi R. \quad (4)$$

If we consider the two cylinders as a Prony brake, the equation for work lost per revolution becomes:

$$W = (N P - M P) 2 \pi D. \quad (5)$$

It is interesting to note that placing equation (4) equal to equation (5) we have:

$$(N P + M P) \sin \mu \, 2 \pi R = (N P - M P) 2 \pi D.$$

Cancelling 2 μ and rearranging, this equation becomes

$$\sin \mu = \frac{(N P - M P) D}{(N P + M P) R},$$

which is the exact form of equation (3).

The support cylinders are shown in Fig. 19.

The essential parts of these cylinders are an upper or guide cylinder A, with a base B, which base is really the cylinder proper, it being recessed on its upper face to permit a very thin film of fluid to receive the pressure of the plunger D. Interposed between the fluid and the plunger is a metal diaphragm C, which completely traps the liquid in the cylinder. The plunger is held away from the walls of the guide cylinder by means of two rings of balls. These balls are fitted very accurately to prevent the plunger from tilting and thus reducing its friction to that of rolling contact. The fluid film may be water, oil, glycerin, or mercury. The United States Bureau of Standards has recommended either a light machine oil or a mixture of alcohol and glycerin. Water is compressible 1 volume in 300,000, per pound pressure per square inch, while mercury has a compression ratio of 1 to 4,700,000.

Mr. A. H. Emery of Glenbrook, Conn., is the inventor of this type of cylinder which he used in the 2,000,000-lb. testing machine now installed at the laboratory of the United States Bureau of Standards. Calibration of these cylinders records a total pressure of 999,817 lb. recorded on the cylinders for an actual load of 1,000,000 lb. on the specimen—an error of 183 lb. in 1,000,000, or an error of less than 0·02 of 1 per cent.

(To be continued.)

THE CONSTITUTION OF THE NICKEL-IRON ALLOYS.*

By D. HANSON, M.Sc., and HILDA E. HANSON
(National Physical Laboratory).

(Concluded from page 623).

The first alloys were removed from the furnace at 800° C. These contained 1, 2, 3, and 4 per cent. nickel respectively. It was found that the alloy FN1 (1 per cent. nickel) consisted entirely of ferrite (Fig. 15), while FN2, FN3, and FN4 were wholly martensitic (Figs. 16 and 17). The lower limit of the critical range, therefore, occurs at 700° C. in an alloy containing between 1 per cent. and 2 per cent. nickel. At the next quenching temperature, 700° C., alloy FN2, which at 800° C. was above its critical range, had now become completely transformed and consisted wholly of ferrite (Fig. 18), FN3 consisted partly of ferrite and partly of martensite (Fig. 19), while FN4 was wholly martensitic (Fig. 20). Fig. 19 is rather interesting, and is a particularly good example of the similarity of the structures obtained in these alloys to those found in carbon steel. The results at lower temperatures were similarly obtained; Fig. 21, for example, represents FN3 quenched from 370° C. This consists largely of ferrite, but contains some small patches of martensite.

Two points are worthy of special note in this part of the diagram. In the first place, it is interesting to observe the effect of nickel in widening the critical range; in spite of the fact that the slowest possible rates of cooling were adopted (900° C. to 350° C. over a period of nearly 1,000 hours) the transformation extends over a temperature range of 200° C. in the 6 per cent. nickel alloy. Thermal curves, taken at ordinary rates, give no indication of this fact. Secondly, the upper limit of the critical range, as determined microscopically, for alloys containing low percentages of nickel, agrees very closely with the transformation line determined by thermal curves.

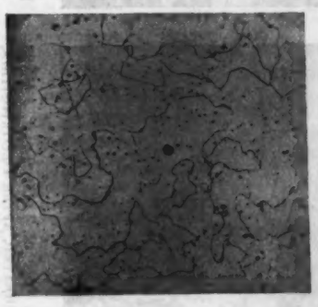


FIG. 15. × 300 DIAM. FN1 QUENCHED AT 800 DEG. C. AFTER 22 HOURS.

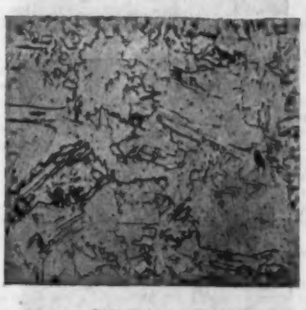


FIG. 16. × 300 DIAM. FN2 QUENCHED AT 800 DEG. C. AFTER 22 HOURS.

FIG. 17. × 300 DIAM. FN4 QUENCHED AT 800 DEG. C. AFTER 6 HOURS.

(ALL MICROPHOTOGRAPHS REDUCED IN REPRODUCTION BY ONE-TENTH.)

When the amount of nickel present exceeds 8 per cent. the determination of the upper limit of the critical range becomes very difficult, and the authors have not found it possible to fix this limit with any certainty by microscopic examination for nickel alloys containing 8 per cent. to 40 per cent. nickel. In view of their desire to confirm and investigate Osmond's hypothetical diagram, this was a disappointment to them, since they had hoped that the slow rates of cooling adopted would lead to the decomposition of the austenite, over this range of composition, at a temperature in the neighbourhood of its equilibrium transformation point. Evidence in support of the truth of Osmond's theory has been given by Benedicks.† He, however, dealt only with one or two alloys, the maximum nickel content being about 11·7 per cent. Additional evidence has, however, been obtained that decomposition of the austenite can take place over a wide range of composition into a duplex mass, of which the two constituents are presumed to be kamacite and taenite, found in meteoric irons, kamacite being identical with ferrite containing nickel in solution.

In the case of alloys containing more than about 8 per cent. nickel, slow cooling at the rates used in these experiments does not appear to lead to decomposition of the austenite until a temperature of about 345° C. is reached; at this temperature, however, prolonged annealing leads to decomposition of all alloys containing 9 per cent. to 30 per cent. nickel, and a duplex structure is found. This may be illustrated by Fig. 22, which represents FN11, and Fig. 23, which represents FN25, after this treatment. When quenched after cooling to 370° C. these alloys had the normal martensitic structure such as is illustrated in Figs. 7 and 10. In the case of FN25 the unaltered martensitic structure was still found when the quenching temperature was 350° C. The other alloys were not quenched at this temperature. Intermediate alloys also showed this decomposition. It was also found to some extent in FN30 quenched at 340° C. (Fig. 24), but in this alloy some of the crystals were found to be quite homogeneous and others duplex. It was at first thought that this appearance might be due to tarnishing of the alloy, but the same pattern appeared repeatedly on re-etching, and it was therefore concluded that it was genuine. FN35 appeared to be homogeneous after all treatments. It therefore appears that the eutectoid line of Osmond's hypothetical diagram extends from 9 per cent. to 30 per cent. nickel approximately, and occurs at a temperature between 350° C. and 340° C.

The breaking down of the austenite at this temperature is amply confirmed by reheating experiments. Re-solution is, however, very slow, and prolonged annealings are necessary before any change is apparent. For example, FN15, FN25, and FN30 were all re-annealed at 368° C. for three weeks after decomposition as a result of slow cooling to 340° C. In FN15 no change resulted; in FN25 the dark etching portions had increased somewhat in extent (Fig. 25), while in FN30 the "ripple markings" on the crystals had become less distinct, and were confined to a few crystals only. In many of the crystals they had disappeared. FN25 was re-annealed for a further fortnight at 370° C. and quenched. The dark etching areas had increased still further in amount, as is shown in Fig. 26. The large extent to which re-solution of the constituent has taken place, with but a slight increase in temperature, suggests strongly that the composition of this alloy is close to that of the eutectoid indicated in Osmond's diagram, which he, however, placed about 40 per cent. nickel. With higher annealing temperatures the change is more rapid. Fig. 27 shows FN11 after re-annealing at 400° C. for a week, while Fig. 28 shows the results of a further annealing at 524° C. for 36 hours. These may be compared with Fig. 22, which shows the original duplex structure before the alloy was reheated. Annealing at still higher temperatures reproduces the martensitic structure usually found in these alloys, indicating a homogeneous solid solution at the quenching temperature.

Reheating experiments were also carried out on the slowly cooled alloys containing low percentages of nickel. The transformation temperatures obtained by this means are indicated in Fig. 29 (page 657), using the same nomenclature as before. It is interesting to observe the reappearance of a martensitic structure when the alloy reaches the critical range, and the structures obtained are very similar to those found in mild steels after similar treatments. In this case, however, martensite does not appear as a result of the solution of a separate constituent in the iron (as in the case of cementite in steel); it depends solely on the existence of the simple transformation of homogeneous austenite into homogeneous ferrite (both containing dissolved nickel) and

* Paper read at the Iron and Steel Institute, at Cardiff, September 21, 1920.

† Benedicks, *Revue de Métallurgie*, 1911.

FIG. 18. × 300 DIAM. FN2 QUENCHED AT 700 DEG. C. AFTER 48 HOURS.

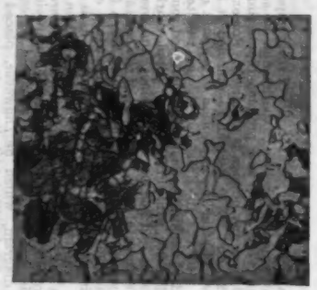


FIG. 19. × 300 DIAM. FN3 QUENCHED AT 700 DEG. C. AFTER 48 HOURS.

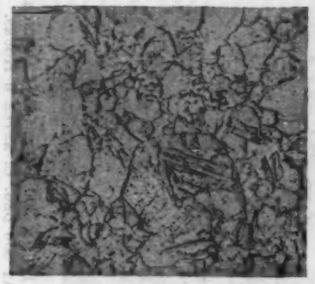


FIG. 20. × 300 DIAM. FN4 QUENCHED AT 700 DEG. C. AFTER 48 HOURS.

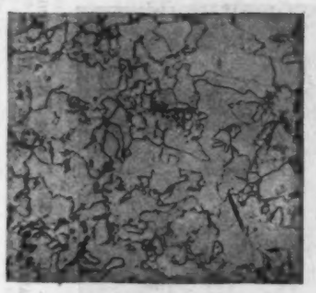


FIG. 21. × 300 DIAM. FN8 QUENCHED AT 370 DEG. C. AFTER 700 HOURS.

FIG. 22. × 300 DIAM. FN11 QUENCHED AT 324 DEG. C. AFTER 288 HOURS.

FIG. 23. × 1,000 DIAM. FN25 QUENCHED AT 345 DEG. C. AFTER 926 HOURS.

FIG. 24. × 600 DIAM. FN30 QUENCHED AT 340 DEG. C. AFTER 144 HOURS.

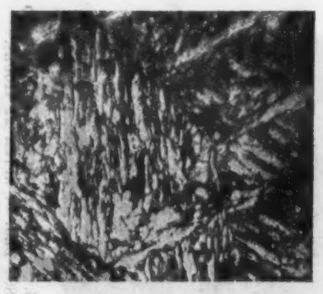


FIG. 25. × 1,000 DIAM. FN25 REHEATED, AFTER DECOMPOSITION, FOR 3 WEEKS AT 358 DEG. C.

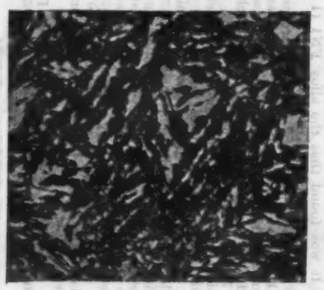


FIG. 26. × 1,000 DIAM. FN25 REHEATED, AFTER DECOMPOSITION, FOR 3 WEEKS AT 358 DEG. C., FOLLOWED BY 2 WEEKS AT 370 DEG. C.

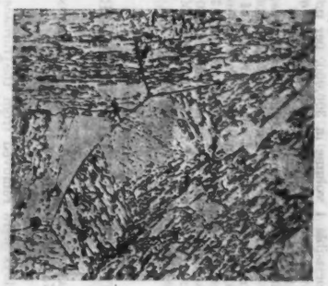


FIG. 27. × 300 DIAM. FN11 —DUPLEX STRUCTURE—REHEATED FOR A WEEK AT 400 DEG. C.

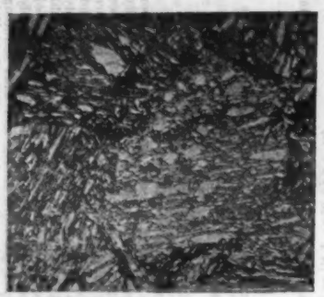


FIG. 28. × 300 DIAM. FN11 —DUPLEX STRUCTURE—REHEATED AT 400 DEG. C. FOR A WEEK, AND AT 524 DEG C. FOR 36 HOURS.

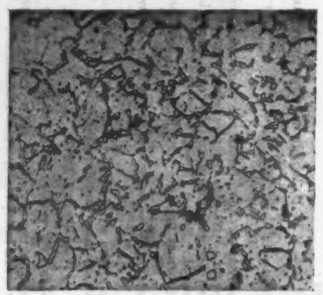


FIG. 30. × 300 DIAM. FN4 REHEATED TO 698 DEG. C. AFTER SLOW COOLING TO 560 DEG. C.

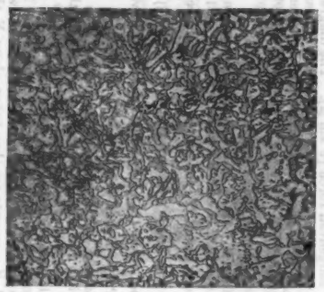


FIG. 31. × 300 DIAM. FN6 REHEATED TO 698 DEG. C. AFTER SLOW COOLING TO 560 DEG. C.

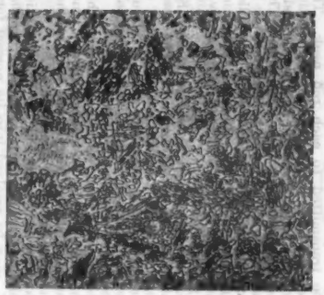


FIG. 32. × 300 DIAM. FN8 REHEATED TO 698 DEG. C. AFTER SLOW COOLING TO 496 DEG. C.

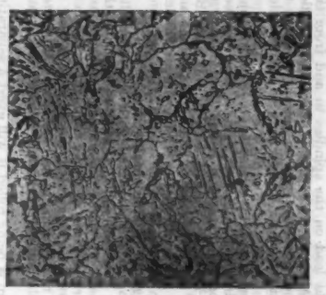
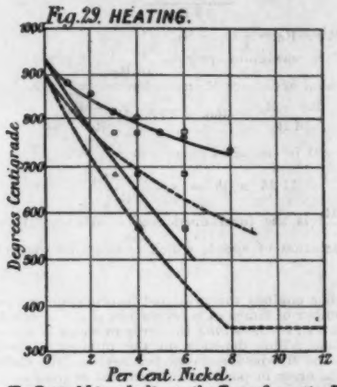


FIG. 33. × 300 DIAM. FN4 REHEATED TO 772 DEG. C. AFTER SLOW COOLING TO 560 DEG. C.

(ALL MICROPHOTOGRAPHS REDUCED IN REPRODUCTION, BY ONE-TENTH.)

does not demand, as has been suggested by some workers, the presence of an equilibrium of the eutectoid type. This observation is of importance, since it indicates clearly that the martensitic structure is characteristic of austenite (in the case of iron alloys) and is not dependent on the presence of iron carbide. In other words, martensite can be produced merely as a result of the partial transformation of γ-iron into α-iron, and is independent of the nature of the added element which facilitates its formation. Figs. 30, 31 and 32 represent the structures of alloys FN4, FN6, and FN8 respectively, reheated to 698° C. after slow cooling and quenched. All these alloys consisted wholly of ferrite before reheating; after this treatment they consist of varying amounts of martensite, together with some untransformed ferrite. Fig. 33 shows the structure of FN4, further reheated to 772° C. Comparison with Fig. 30 shows that the amount of martensite has increased. The alloys do not appear

Fig. 29. HEATING.

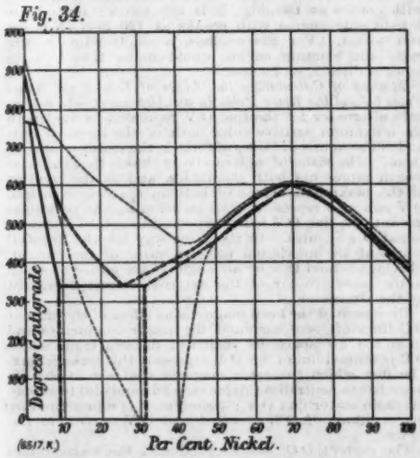


The Dotted Lines Indicate the Transformation Range on Cooling.

○ *Quenched Alloy consists of Martensite.*
□ " " " - *Martensite and Ferrite.*
△ " " " - *Ferrite.*
◎ *Arrest Points on Heating Curves.*

(8517.1)

Fig. 34.



(8517.2)

to become completely austenitic until the transformation temperatures indicated by the heating curves have been exceeded.

It has long been known that the nickel-iron alloys undergo transformations which take place extremely slowly on account of the low temperatures at which they occur, and the experimental difficulties in studying them are consequently very great. It was not until Benedicks succeeded in bringing about the decomposition of certain nickel-iron alloys that any definite experimental knowledge of the low temperature transformations of these alloys was obtained. He succeeded in obtaining his results by cooling his alloys slowly in a large furnace, and his work suggested that the rates of cooling required were not nearly so slow as had previously been supposed. The present authors, knowing that they had at their disposal apparatus which would give rates of cooling very much slower than those used by Benedicks, hoped to be able to determine, without great difficulty, the conditions under which the changes took place. Their preliminary experiments, however, soon showed that their alloys required much slower rates, and they thought that this might be due to their purity. This view has been confirmed by conversation with Dr. Guillaume, who states that he has found that carbon, even in very small quantities, has a marked effect on nickel-iron alloys, and renders them much more liable to undergo changes. In fact, in the manufacture of such things as length standards, for which some of these alloys are suitable, every care is taken to keep this element as low as possible. In spite of these difficulties, however, the authors have been able to show duplex structures in these alloys over a range of composition extending from 9 per cent. to 30 per cent. nickel, and firmly to establish Osmond's hypothesis.

From the data obtained, an equilibrium diagram has been drawn for these alloys which is shown in Fig. 34. The thin dotted lines show the transformation points obtained from thermal curves and conductivity measurements, and indicate the deviation of the transformation points from their probable equilibrium temperatures. While no high degree of accuracy can be claimed for this diagram, it is probably not far from correct. In any case, the type of the diagram appears to be definitely established.

The authors wish to acknowledge the assistance they have received from a number of their colleagues, notably from Mr. P. Ward, B.Sc., and Miss A. M. O'Hea, who have carried out most of the analyses described in the paper, and from Mr. E. A. Coad Pryor, B.A., who gave them considerable help by supplying refractory crucibles and other articles required during the research; finally, they would like to record their indebtedness to Dr. W. Rosenhain, F.R.S., for the interest he has taken in this work.

VIBRATION.

*Including that of Crankshafts, Flywheels and Alternating Current Generators, and the Paralleling of Alternators.**

By Julius Frith, M.Sc., M.I.E.E., Member.

Vibration in General.—Anything which is movable at all is capable of being set into a state of vibration. This state might be defined as a number of recurring excursions either from a position of rest or from what is mechanically very similar, from a state of uniform motion. For instance, a building may be set into vibration by a traction engine in the road outside. A sound carried by the wind is an example of the second-mentioned class of vibration.

For this general definition of vibration it is immaterial whether the excursions take place both ways from the position of rest, as in the case with both the instances just cited, or are all on one side, such as a hen on hot bricks. Most of the vibrations met with in engineering are, however, of the former sort.

Vibration may be "natural" or "forced"; that of a tuning fork is "natural," *i.e.*, there is one definite rate of vibration at which the fork vibrates and it would show the utmost reluctance to being made to vibrate at any other rate. A boy being shaken by the shoulders is an example of "forced" vibration in that the whole state of motion is inflicted on him from without and the frequency is wholly at the comm.and of the vibrating forces and is not dictated at all by the body's own natural frequency.

Any body which possesses mass or inertia and which, if displaced from its position of rest experiences a force tending to restore it to that position, has a "natural" frequency depending only on two things:—

1. The inertia of the moving mass, and
2. The strength of the force which tends to restore it to its position of rest.

The general expression which gives the frequency of the vibration depends on these two quantities. The form that this expression takes depends on whether the movement is in one straight line, such as in the case of a weight suspended vertically by a spring and vibrating up and down, or whether the movement is one of oscillation round an axis. In the first case the frequency or number of complete swings per minute =

$$54 \cdot 2 \sqrt{\frac{\text{restoring force in pounds weight per foot of displacement}}{\text{moving mass in pounds.}}}$$

In the second case frequency =

$$54 \cdot 2 \sqrt{\left(\frac{\text{moment of restoring force in pounds weight at one foot radius per foot of circumferential displacement}}{\text{moment of inertia of moving mass in pounds} \times \text{feet}^2}\right)}$$

An example or two will show how these expressions are used.

1. Hang a 2-lb. weight up on a spring and measure the increased length of spring = say, 6 in. Start it vibrating up and down. It should do

$$54 \cdot 2 \sqrt{\left(\frac{2 \times \frac{12}{6}}{2}\right)} = 76$$

complete swings per minute.

2. Clamp one end of a steel shaft, the other end of which carries a flywheel with its mass = 20 lb. concentrated in its rim of 3 ft. in diameter. Wrap a string round the rim, hang a 10-lb. weight to it and measure the inches it rotates = 3·3 in. say. Frequency should =

$$54 \cdot 2 \sqrt{\left(\frac{10 \times 1 \cdot 5 \times \frac{12}{3 \cdot 3}}{20 \times (1 \cdot 5)^2}\right)} = 60$$

swings per minute.

In the case where the shaft is not clamped at the end, but is attached to a second flywheel of moment of inertia I_2, the system thus formed has only one natural frequency, which can be found exactly as above by clamping the shaft at such a point that the distance between the two flywheels is divided in the inverse ratio of the two moments of inertia. The two ends will then have the same frequency. Instead of clamping the shaft, it is easier to clamp one wheel and measure the stiffness of the whole length of shaft, in which case the natural frequency of the system when both wheels are free to vibrate will =

$$54 \cdot 2 \sqrt{\left(\frac{\text{moment of restoring force for the whole shaft per unit displacement}}{\frac{I_1 \times I_2}{I_1 + I_2}}\right)}$$

In certain cases one wheel may be represented by the inertia of the moving parts of an engine.

It will be noted that the amplitude of the vibration does not affect the frequency provided only that the restoring force is proportional to the displacement.

Causes of Vibration.—It will be surmised from the above that a state of vibration may be set up in almost anything, and by the use of recently-developed apparatus this is found to be the case, hardly anything being entirely free from it. In general, however, this vibration is of the "forced" description, *i.e.*, is not helped by the system vibrated; the amplitude is small and the movement itself soon dies out by doing work against friction once the disturbing force is withdrawn. If, however, the disturbing force by accident or design coincides with the natural period of vibration of any system, then a quite different set of conditions obtains: the effect is then cumulative, the amplitude of the vibration increases to an indefinite extent and is only limited in extent either by friction or by a yielding of the material of which the system is composed.

Suppose a flywheel and shaft, the period of which is worked out as above at 60 per minute, is the crankshaft and flywheel of a 60-r.p.m. single-cylinder single-acting steam engine, or of a 120-r.p.m. Otto cycle gas engine; then the irregularities in the turning effort, synchronising with the natural period of the shaft plus flywheel will cause an oscillation of ever-increasing amplitude to be superimposed on the regular part of the rotation, this amplitude will probably only be limited in extent by the fracture of the shaft or the breaking loose of the flywheel from it by shearing the key or the coupling bolts.

Other Restoring Forces.—The elasticity of a shaft is not the only form restoring forces can take. Imagine an engine to be coupled to its load through a flexible coupling composed of an inner and an outer member joined together by elastic cords, which when no torque is being transmitted would take up their shortest length and be truly radial; when called upon to transmit torque they would stretch and become more tangential, the inner member being displaced with regard to the outer member, although both would be rotating at the same average number of revolutions per minute. The elastic pull of these cords would constitute a restoring force precisely similar in nature to that of the elasticity of a shaft and capable of being measured by the methods indicated in the examples above.

Now if the driving effort and the load were perfectly uniform all would be well; there would be a small angle of lag of the driving member behind the driven member, which angle would be proportional to, and a measure of, the torque transmitted. It would not be a difficult matter to devise some method of indicating this angle of lag even whilst both members were rotating and so making a transmission dynamometer. If over the load over-ran the engine and the power was momentarily reversed, the angle would reverse and appear the other side of the mean position.

Now if there were revolving masses on either side or both sides of this elastic coupling the system would, of course, have a natural frequency of its own; then if irregularities in either the engine or the load synchronised with this natural frequency a swing of increasing amplitude would result, which would in time stretch the elastic cords more and more till they broke and the coupling ceased to function.

Engine-driven Alternating Electric Generators.—Now the foregoing is a very exact mechanical analogy to the case of an engine driving an alternator; in fact, I would go further than this and assert it is all an engine maker needs to know about an alternator. The magnetic lines of force between the magnet poles and the stator are elastic cords; the magnet poles do lead in front of the stator poles by a definite angle which is very nearly proportional to the load. The magnet poles can be allowed to stray away by a small amount in front or behind their correct position, and if this amount is exceeded the magnetic lines are broken and the machine falls out of step. If the generator at any time motors the engine this angle of lead reverses and the magnet poles lag behind the stator poles. The wattmeter in circuit would be calibrated to read angular displacement between driving and driven poles, and by this steadiness or otherwise of its reading the variations of this angle and, therefore, the deviations from uniform turning, can be watched.

The restoring force is evidently equal and opposite to the driving torque, and its moment in foot-pounds weight =

$$\frac{\text{B.H.P.} \times 33{,}000}{\text{R.P.M.} \times 2\pi} \text{ or } \frac{\text{B.H.P.}}{\text{R.P.M.}} \times 5{,}250$$

The angular displacement for any given load should be quite evident to the electrical designer of the alternator, and is generally between 10 and 15 electrical degrees, an electrical degree being 1/180th of the distance between adjacent poles. A simple graphical method of calculating θ is given in the appendix. The electrical designer also generally allows the pole to be within plus or minus three or four electrical degrees of where it ought to be on the supposition of perfectly uniform turning; this is to allow of a certain amount of cyclic irregularity of the engine. Engine makers usually describe the maximum cyclic irregularity of their engine as a speed error, which conveys nothing to the electrical man who does not mind how fast the pole moves about or indeed would not mind it stopping quite still for a bit,

* Paper read before the Manchester Association of Engineers, October 23.

provided it did not stray beyond the boundaries of error in position which he has laid down for it. As I have found a considerable doubt existing as to how to translate speed error into position error, or *vice versa*, an approximate solution for this is given in an appendix, which solution gives quite sufficient accuracy to insure satisfactory running provided the engine does not contain in its cyclic irregularity any periodic disturbing force which synchronises with the natural frequency of the alternator.

It is desired to emphasise the fact that this matter is purely one of a mechanical vibration set up first of all by the engine and then picked up by the alternator by virtue of its inertia and mechanical driving torque. The only, so to speak, supernatural element in the problem is the fact that the restoring force is the pull exerted by magnetic lines; this pull is just as mechanical as the pull of gravity on the bob of a pendulum.

The only reason that the thing is forced on our attention at all is that by reason of the engine and alternator playing see-saw as it were, the pole ceases to walk in the narrow way and gets outside the limits prescribed for it by the electrical authority.

Alternators in Parallel.—If one engine drives one alternator and there is nothing connected to the electrical mains which has any natural frequency, *i.e.*, the load consists of lamps or furnaces and not of big synchronous motors, then there would be no great harm in a cyclic irregularity large enough to cause a greater error in position than that specified above. It is not, however, advisable to supply at a varying frequency, as this would call for exactly corresponding changes in speed in any synchronous machinery, generators or motors, anywhere on the mains, *i.e.*, would set up a vibration superimposed on their regular speed. This vibration would be either "forced" or "natural" (see definitions earlier in the paper). If it were forced the inertia of the synchronous machinery would resent an attempt to increase and decrease its speed rapidly, and surges of power would result. If, on the other hand, the vibration set up was one of the same period as the natural frequency of any of the other machinery this latter would seize upon it with avidity and proceed to increase it till the swing got beyond the possible bounds and one or other of the machines would come out of step.

Synchronous electric machinery in parallel is analogous to a collection of machines, engines, &c., all connected together by means of spur gearing; all must either run at a perfectly uniform speed or have exactly the same irregularities, and any wheel which starts swinging will tend to communicate that swing to all the others. In the same way an alternator may be set into vibration either by its own engine or the engine of any of the other sets with which it is in parallel or by any disturbance on the system, such as a motor coupled to an air compressor. So that it is necessary in putting in a new set, say, in a generating station, not only to make sure (*a*) that the new engine does not synchronise with its own alternator, but also (*b*) that it does not do so with any of the existing alternators or other synchronous machinery, and (*c*) that none of the existing engines synchronise with the new alternator.

It is obvious that an engine may give out disturbances of many different frequencies; for instance, a single-cylinder Otto cycle gas engine will have a disturbing frequency of half its number of revolutions per minute; with more than one cylinder it will still have the above frequency and also another equal to this multiplied by the number of its cylinders. The lowest a steam engine could have would equal the number of its revolutions and the highest would be the total number of power impulses, per minute.

If the disturbing forces have a frequency nearly but not quite equal to the natural frequency of the thing vibrated we have the phenomena of beats, *i.e.*, the amplitude increases and diminishes again with a rhythm of longer and longer period as the two frequencies approach one another. In general these beats begin to become dangerous when the two frequencies are within 20 per cent. of each other, so that for safety the two should be kept further apart than that. This circumstance explains the fortunate fact that it is not necessary to be able to calculate the natural frequency of a shaft and flywheel of an alternator with any very great accuracy, as what is generally necessary, is to keep well away from it. It is also fortunate that the quantities which have to be calculated, and about the precise values of which there may exist some doubt, are under a square root, so that a 10 per cent. error there would only make a 5 per cent. error in the calculated frequency.

In the case of an alternator the second of the general expressions for natural frequency can be modified to render it more easily applicable. For instance, let θ be the angle in electrical degrees by which the magnet poles lead in front of the stator poles for an output of K kilowatts. θ can be translated to feet circumference at 1 ft. radius (radians) by dividing it by half the number of poles and by $\frac{360}{2\pi}$. Dividing K by 0·746 gives horse power; and as before, expressing the moment of inertia I, in pound-foot^2 units, this gives us natural frequency =

$$24{,}000 \times \sqrt{\frac{K \times \text{Poles}}{\text{R.P.M.} \times I \times \theta}}$$

complete swings per minute.

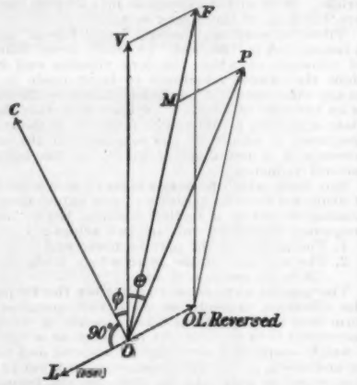
For example, a 200-kw. 50-cycle 200-r.p.m. alternator might very well have an angle of lag between its stator and rotor poles of 15 electrical degrees at full load and a combined flywheel M.k^2 of 100,000 lb.-ft.^{2} units contained partly in its own rotor and partly in the engine flywheel. The alternator would have 30 poles and the natural period of the system consisting of alternator and flywheel would =

$$24{,}000 \times \sqrt{\frac{200 \times 30}{200 \times 100{,}000 \times 15}} = 108 \text{ per min.}$$

If a steam engine was to drive the alternator, the lowest frequency disturbance would be at 200 per minute, which would be quite satisfactory, for a little consideration will show that though a disturbance of the lower frequency may set up a swing in a system having a higher frequency which is an exact multiple of the other, the converse does not hold. For, imagine a pendulum swinging 100 complete swings per minute acted on, say, by puffs of air at 200 per minute; if the first puff was in the direction of motion and so aided the swing, the second would meet the pendulum coming back and tend to stop its motion by the same amount.

If, however, the engine were an Otto cycle gas engine it would have a disturbing effect of 100 impulses per minute which would be far too near the 108 to be safe, in which case something would have to be done. The most obvious thing would be to alter the mass of the flywheel; here one has the choice of either increasing the inertia and so lowering the natural frequency, in which case the set would run through a critical speed in starting-up, or reducing the flywheel effect and so bringing the frequency between the two danger zones round 100 and 200 per minute. Of the two alternatives the former commends itself to me as the period during which the two synchronise is so short that the amplitude would not have time to become excessive, the effect being essentially a cumulative one. The latter method is too suggestive of steering between Scylla and Charybdis to be altogether comfortable, although the risk is not prohibitive should there be no other way out.

The problem can also be attacked from the electrical end by means of an alteration in the angle θ. The readiest way to do this in an existing alternator is to alter the magnetising force. If nothing else is done the terminal voltage will, of course, be affected, which may be permissible for purposes of experiment, but which can be corrected by a corresponding alteration in the magnetic circuit, either in the section of the iron in poles or yoke and more easily in the air space which may be shortened by packing up the poles or altered in area by means of the pole tips. The precise way



in which this alteration in magnetising force affects the angle θ is readily seen from the figure in the appendix. It will be seen, in this connection, that the very circumstance we were just now congratulating ourselves over works both ways in that to effect a given alteration in frequency, the inertia or the angle θ must be altered twice this amount.

APPENDIX.

Cyclic Irregularity—Connection between Error in Speed and Error in Position.—First consider a single-cylinder, single-acting steam engine admitting full pressure steam for the full stroke and then opening to atmosphere. During this stroke the flywheel is being accelerated from its minimum to its maximum speed, during the return stroke the flywheel is taking the load, giving up energy by lowering its speed. So that twice in a revolution, in the middle of each stroke the engine is running at its mean speed. Now imagine another flywheel running alongside this one but at a perfectly uniform speed equal to the mean speed of the engine under consideration. Suppose a chalk mark ruled parallel to the shaft across the face of the two wheels at the middle of the power stroke, *i.e.*, at an instant when the speed is equal to the mean speed; for the next half revolution until the middle of the return stroke, the speed is more or less above the mean speed, but always above it, *i.e.*, the engine flywheel is moving faster than the perfect one, and therefore the two chalk marks will be separating all this time. After this has gone on for half a revolution the engine speed commences to fall below the mean, and as its chalk mark is in front of the other, the two will commence to approach each other. From this it is evident that the maximum distance apart of the chalk marks is the maximum error in position and occurs at the middle of the return stroke. At the middle of the next power stroke the two chalk marks are together again and the process repeats.

If R_0 = the mean speed in revolutions per minute, R_1 the lowest and R_2 the highest momentary speeds, the time during which the lines have been separating is half the time of a revolution = $\frac{1}{2\,R_0}$ minutes. The average speed during that time has been $\frac{R_2 + R_0}{2}$ r.p.m. The speed of the ideal flywheel has been R_0, the difference in speed which is the relative speed of the two chalk marks has been $\frac{R_2 + R_0}{2} - R_0$ r.p.m. This error in speed has continued for $\frac{1}{2\,R_0}$ minutes, therefore the fraction of a revolution separating the two marks at their greatest distance apart =

$$\frac{R_2 + R_0}{2} - R_0 \times \frac{1}{2\,R_0} = \frac{R_2 - R_0}{4\,R_0}$$

It will be noticed in the above that although the speed of the engine is alternately above and below that of the ideal wheel, the chalk mark on the engine's wheel is always in front of the other, so that the maximum error in position is really plus or minus half the above =

$$\frac{R_2 - R_0}{8\,R_0}$$

Now $R_2 - R_0 = \frac{1}{2}R_2 - R_1$.

Therefore maximum error = $\frac{R_2 - R_1}{16\,R_0}$ of a revolution

or, expressed in degrees of circumference =

$$\frac{R_2 - R_1}{16\,R_0} \times 360 = 22{\cdot}5\ \frac{R_2 - R_1}{R_0}$$

or expressed in electrical degrees =

$$11{\cdot}25 \times \text{Poles} \times \frac{R_2 - R_1}{R_0}$$

$\frac{R_2 - R_1}{R_0}$ is the form most engine makers give the cyclic variation of speed, which is often of the order of $\frac{1}{500}$.

For other engines the principal information required is the number of times in a revolution that the speed is put right, *i.e.*, for how long the error in speed is allowed to continue. This depends on the number of power impulses the flywheel receives per revolution. Calling this N, the error in position in electrical degrees =

$$\frac{11{\cdot}25 \times \text{Poles}}{N} \times \frac{R_2 - R_1}{R_0}$$

N for the engine considered = 1. If the single-cylinder engine were double-acting it would be two, and is still two, for any double-acting tandem engine. For a side-by-side compound with cranks at 90 deg. it is four; with cranks at 180 deg., it is two again; for a triple side-by-side engine with cranks at 120 deg., N = six, and so on. For gas engines, a single-cylinder Otto cycle single-acting engine would make N = $\frac{1}{2}$, for a tandem ditto 1, and so on.

Method of Calculating the Angle of Lag of the Stator Poles behind the Rotor Poles in an Alternator.—In a two-pole alternator let the line O V represent by its length the maximum positive value both of the terminal volts and of the number of lines of force in the stator producing them. The scales of each can be so chosen that the same length represents both quantities, and as the position of the maximum values of both in space is identical, O V can also represent their position at one particular instant, the line O V being supposed to rotate clockwise round O as centre. In the same way let the line O C represent the maximum positive value of the current. This lags behind O V by an angle ϕ the cosine of which is the power factor of the external circuit being fed by the alternator.

By reason of the local magnetising effect of the current O C lines of force surround the stator conductors and cross the air space 90 electrical degrees from where O C is a maximum: let O L represent this leakage flux. The flux which the rotor magnets send across the air space has to neutralise this leakage flux and also to supply the main stator flux O V; therefore, it is represented by the resultant of O L reversed and O V or O F in the figure.

The current O C, besides producing the leakage flux O L, has a direct demagnetising effect on the rotor magnets, the maximum effect of which is along the radial line half-way between the maximum positive and negative values of O C or 90 deg. from each, *i.e.*, in the same direction as O L.

As before, by a suitable choice of scale let the line O L represent this demagnetising effect of O C. Using this same scale, mark off on O F a length O M to represent the magnetisation required for the flux O F. The rotor poles not only have to supply this, but have to overcome the demagnetising effect of the stator current represented by O L, and they are, therefore, represented in magnitude and direction by the resultant of O L reversed and O M, shown as O P in the figures. The magnitude of O P or the strength of the rotor pole is interesting to the designer, but it is its direction which interests us at the moment, as it will be seen that the angle θ between O V and O P is the lag of the stator pole O V behind the rotor pole O P, for an electrical output of O V volts and O C amperes at a power factor = cos ϕ, which is what we set out to discover and which I have called θ in the paper.

For a mathematical proof of the expression for time of vibration, and for methods of working out other and more complicated problems, including the substitution of an equivalent flywheel for the reciprocating parts of an engine, see "The Breaking of Shafts in Direct-Coupled Units, due to Oscillations set up at Critical Speeds," by Julius Frith and Ernest H. Lamb, Journal of the Institution of Electrical Engineers, vol. xxxi, page 646.

For more detail of the construction of the vector diagram for finding θ see "Alternating Current Design," by Julius Frith. Harper and Brothers.